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ORIGINAL ARTICLES.

I.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(PLATE XIV.)

(*Continued from the February Number*, p. 77.)

MY next four species are linked together by their avicularia, which in each case have the side walls infolded over a long deep-set area.

Membranipora sagittaria, nov. Pl. XIV, Figs. 1–3.

Zoarium free or encrusting, always unilaminate.

Zoœcia elliptical; length of area ·42 to ·52 mm., with ·48 mm. a fair mean; breadth ·3 to ·35 mm.; the earlier specimens have practically common walls, the later ones show a progressive tendency to separation of the zoœcia and sometimes a tendency to develop a second margin which reduces the area ·29 to ·31 mm. in length and ·15 to ·2 mm. in breadth.

Oœcia very abundant but rather fragile, in the earlier specimens long and narrow, in the later ones showing a progressive tendency to broaden and fall back from the area.

Avicularia of two types. (*a*) Accessory: in the zone of *M. coranguinum* small oblong rings lying at the head of the zoœcium and occurring very regularly in pairs on either side of, and lying against, and slightly overlapping the oœcium, but nearly always failing to occur when a vicarious avicularium adjoins. In the specimen from the lower part of the *Actinocamax quadratus* zone, shown as Fig. 2, they are developing in two directions, in one becoming exsert and overlapping their surroundings, in the other sinking into the gradually deepening furrows between the zoœcia and becoming mere triangular indentations; the latter line of development alone persists in the specimen from the upper part of the *Act. quadratus* zone shown as Fig. 3. (*b*) Vicarious: oblong cells with a long narrow elliptical aperture; there is a strong transverse bow-shaped ridge at the head of the cell, immediately below which the bounding walls are very sharply bent inwards until they overhang the aperture and almost meet in the middle line; they curve slowly back again and disclose a fairly wide front wall at the foot of the cell; just below the point at which they cease to overhang the aperture a pair of stout denticles are developed from the margin of the aperture.

Found in the *M. cor-anguinum* zone at Gravesend, in the *Act. quadratus* zone in various parts of Hampshire, and in the *Belemnitella mucronata* zone in the Isle of Wight.

MEMBRANIPORA DOLIUM, nov. Pl. XIV, Figs. 4–6.

Zoarium free or encrusting, always unilaminate.

Zoœcia large; length of area ·35 to ·51 mm., with ·45 mm. as a fair mean; breadth ·28 to ·43 mm., with ·36 mm. as a fair mean; the giant form from the Cromer–Weybourne Chalk shown in Fig. 6 gives average length of area ·65 to ·7 mm. and breadth ·5 to ·55 mm.; the broad margins are quite distinct; the areas are more or less barrel-shaped, owing to the strong tendency at the head to a straight margin, and at the foot to a slight intrusion of the preceding oœcium.

Oœcia abundant, large, and globose.

Avicularia of two types. (*a*) Accessory: a pair of rings very uniformly present set against the areal margin at the upper corners. (*b*) Vicarious: elliptical cells with a wide elliptical aperture surrounded by a narrow front wall; at about one-third of the way down the cell the bounding walls are bent inwards until they slightly overhang the aperture; they continue for another one-third of the cell to overhang the aperture in a slowly increasing degree, and are then cut back to the edge of the aperture at a right angle, and for the rest of the length of the cell coincide with the margin of the aperture.

Found in the *Act. quadratus* zone at various points in Hampshire, and with *B. mucronata* at Bramford in Suffolk, and in the Cromer–Weybourne Chalk, but not yet at Trimingham. It agrees very closely with *M. lyra*, as figured by Hagenow,[1] except that the latter has not vicarious avicularia according to either figure or description, and it is not likely that Hagenow would have overlooked them if they did occur.

MEMBRANIPORA ANGUIFORMIS, nov. Pl. XIV, Figs. 7 and 8.

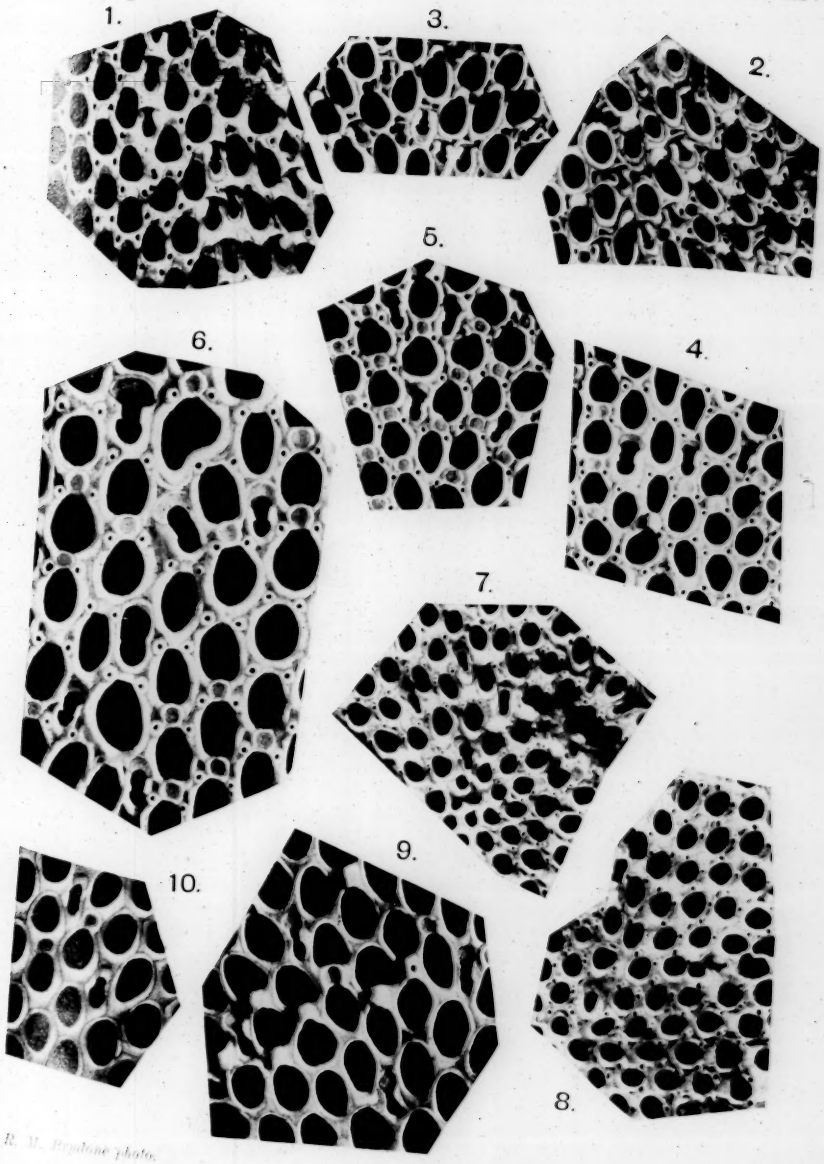
Zoarium unilaminate, always encrusting.

Zoœcia small, length of area ·27 to ·32 mm., breadth ·23 to ·26 mm., subcircular, with very distinct margins, and often separated by deep fissures.

Oœcia very abundant, but very fragile; the specimens shown by Fig. 7 are the only ones I have seen, and unfortunately three out of the four have become defective and the fourth cracked since that photograph was taken; they are very wide, but too short to reach the area, with straight free edges, their general shape being much that of a beehive; the traces they leave when broken away are very indistinct.

Avicularia of two types. (*a*) Accessory: a pair of perforated tubercles very constant in occurrence, set on the margins at the upper corners of the zoœcia, and having nearly always in mature zoœcia a low semicircular extension upwards, with a shallow pore at the change of level; they then combine with the zoœcial margin to give a strong suggestion of the upper half of a snake. (*b*) Vicarious: largish elliptical cells, with a long narrow aperture tapering slightly from head to foot, and constricted near the foot by two small paired

[1] Loc. cit., p. 98, pl. xi, fig. 2.



R. W. Hopkins photo.

Chalk Polyzoa

denticles, and surrounded by a narrow front wall which is deep-set at the head of the cell, and rises steadily towards the foot; in the centre of the cell the bounding walls are bent rather sharply inwards to the edge of the aperture and back again; these avicularia have a strong general resemblance to those of *M. invigilata*, but it will be observed that the denticles in *M. anguiformis* and *M. sagittaria*, being processes from the margin of the aperture, are not analogous to the denticles of *M. invigilata*, which are processes from the bounding wall.

Found only at Trimingham.

MEMBRANIPORA LANGI,[1] nov. Pl. XIV, Figs. 9 and 10.

Zoarium unilaminate, always encrusting.

Zoœcia often large, but very variable; length of area ·43 to ·7 mm., with ·65 mm. as a fair mean in good specimens; breadth ·32 to ·5 mm., with ·45 mm. as a similar mean; boundaries clearly marked owing to differences of level between adjoining zoœcia but not by any furrow.

Oœcia long and rather straight-sided, often projecting slightly over the area of the succeeding zoœcium, and generally rising from a slight protrusion of the margin of the aperture; in one zoœcium in Fig. 9 the protrusion has been formed, but no oœcium has developed from it.

Avicularia of one type (vicarious) only, rather low-lying, and forming the initial cells of new rows of zoœcia; elliptical, with wide elliptical apertures surrounded by a fairly wide front wall at the head of the cell and by a narrower one at the foot, but overhung considerably in the middle by the very symmetrically inbent edges of the bounding walls, which present the outline of an hour-glass.

Found abundantly at Trimingham, occasionally in the Cromer–Weybourne Chalk, and once in the *Act. quadratus* Chalk of Hampshire.[2]

EXPLANATION OF PLATE XIV.

(All figures × 11 diam.)

FIG. 1. *Membranipora sagittaria*, zone of *M. cor-anguinum*, Gravesend.
,, 2. Ditto, zone of *Act. quadratus* (lower part), Hants.
,, 3. Ditto, zone of *Act. quadratus* (upper part), Hants.
,, 4. *M. dolium*, zone of *Act. quadratus* (upper part), Hants.
,, 5. Ditto, zone of *B. mucronata* (?), Bramford, Suffolk.
,, 6. Ditto, Cromer–Weybourne Chalk.
,, 7. *M. anguiformis*, Trimingham.
,, 8. Ditto, Trimingham (another specimen).
,, 9. *M. Langi*, exceptionally preserved, Trimingham.
,, 10. Ditto, in ordinary preservation, Trimingham.

II. — ON A NEW SPECIES OF FOSSIL COCKROACH, *ARCHIMYLACRIS* (*ETOBLATTINA*) *WOODWARDI*, FROM THE SOUTH WALES COAL-FIELD.

By HERBERT BOLTON, F.R.S.E., F.G.S., of the Bristol Museum of Natural History.

(PLATE XV.)

THE Orthopteron wing which forms the subject of the present paper was obtained by Mr. David Davies from a dark-blue shale, about 10 feet in thickness, overlying the No. 2 Rhondda coal-seam in

[1] Dedicated to W. D. Lang, Esq., of the British Museum (Natural History).

[2] *Erratum*: p. 76, l. 29, *for* construction *read* constriction.

Clydach Vale (see Plate XV). The shale decreases to the east, dying out wholly 2 miles beyond the colliery, giving place to sandstone. I am indebted to Mr. Davies for the opportunity of describing the specimen.

The wing or tegmina lies upon a very small piece of black shale and shows the upper surface, which is gently convex along the middle, somewhat hollowed over the mediastinal area, and more strongly curved along the inner margin and over the anal area. The basal portions of all the veins, and the whole of the internomedian and anal veins are well elevated above the general surface, the rest lying, as do all the smaller branches, below the general level. The 'cross-veins' of Scudder are remarkably well preserved over the whole wing surface, forming a multitudinous series of fine close-set parallel ridges, which give a ladder-like appearance to the areas lying between the veins. The general impression is that of a finely wrinkled integument, which it really is, for where the chief veins or their branches are sunken, the 'cross-veins' pass clean across the vein without any break, or any visible connexion. This is especially noticeable in the mediastinal area, where the wrinkles can be traced over several of the tertiary branches of the vein in succession. All the wing anterior to the internomedian area, and with the exception already noted, i.e. the base of the principal veins, is distinguished by the veins lying in shallow troughs, between which the wing-structure rises in a well-rounded surface. The internomedian and anal areas, on the other hand, form an inner and smaller division of the wing in which all the veins are in high relief, the wrinkled surface lying in flattened hollows between.

The wing appears to be complete, but is encroached upon by the shale in two small places on the outer margin. Considering the wing as a whole, it may be described as stout and robust, much shorter for its width than is seen in most species of *Etoblattina*, and possessing a regularly convex anterior margin which passes insensibly into the outer border; the latter is almost semicircular in outline, whilst the inner border is so feebly concave as to at first appear perfectly straight. At the base of the wing the full course of the veins cannot be traced to their point of attachment.

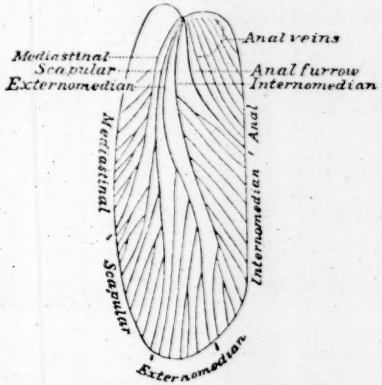
The mediastinal vein curves forward for two-thirds of its length, then backwards, but not so sharply as the margin of the wing, which it therefore continues to approach. Finally it bends outward and runs to the margin, reaching the latter a little beyond the middle. The whole course of the vein is somewhat sigmoidal, and not so straight, for example, as shown by Scudder in *E. venusta*.[1]

Sixteen secondary veins at least spring from the mediastinal, four of which do not bifurcate. In the basal third of the area the presence of secondary veins cannot be distinguished. All the secondary veins approach the margin obliquely, with the exception of the last, which curves forward to meet it. The scapular vein forks at about the first quarter of its length into two unequal secondary branches. The anterior branch, which is the smallest, runs somewhat parallel to the

[1] Scudder, "Palæozoic Cockroaches": Boston Soc. Nat. Hist., vol. iii, pl. vi, fig. 12.

mediastinal vein, breaking up into fine tertiary veins, the first two of which again fork before reaching the margin. The median branch of the scapular divides into two equal tertiaries, the anterior forking twice before reaching the margin, and the hinder forking but once.

The scapular area occupies a little less than the outer half of the anterior margin of the wing, and almost exactly half of the external margin. Notwithstanding a general correspondence of the scapular vein with that of *E. venusta*, it occupies more of the anterior margin, owing to the forward curve of the anterior secondary vein, a curve which is continued in the tertiary branches, causing them to reach the margin a little beyond the middle of the latter's length.



Outline figure of one of the tegmina of *Etoblattina mazona*, from the Carboniferous beds of Illinois, with the nomenclature of the veins as used by Heer and followed by Scudder (see Bulletin U.S. Geological Survey, No. 124, 1895, "Revision of the American Fossil Cockroaches, etc.," p. 37, fig. 3).

The *externomedian* vein follows a sub-parallel course to the hinder secondary of the scapular, and remains undivided until it reaches the secondary forking of the latter. In this respect, the specimen again differs from *E. venusta*, where the forking occurs at a lower level. An examination of Scudder's drawing shows that the primary forking of the externomedian, and the secondary forking of the scapular, lie in an oblique line directed forwards and outwards, whilst in the present case the same points of division lie upon a straight line bisecting the wing. The externomedian in the present specimen shows no internomedian branch in its lower third such as is indicated by Scudder. Beyond the first fork the hinder branch divides twice, so that the externomedian divides up into four branches, all of which reach the margin without further subdivision. The externomedian area is very small, and subtends not more than one-third of the tip of the wing. The *internomedian* vein follows a course parallel to the main axis of the externomedian, and after curving backwards a little in the first quarter of its length, passes straight outward to the hinder edge of the wing tip, giving off to the inner margin nine simple straight and unforked branches. The marginal area occupied by this vein and

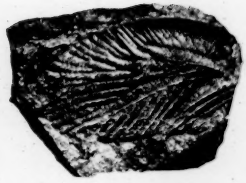
its branches includes the outer two-thirds of the inner margin, and a small portion of the outer or tip of the wing. A slight fold separates the anal veins from the lowest branch of the internomedian, and divides off a small triangular lobe from the rest of the wing. The anal lobe thus formed is crossed by four anal veins which run parallel, and in the case of the basal two at least fork before they reach the margin. In the almost straight course which the anal veins pursue to the inner margin they are in marked contrast to those of *E. venusta*, whilst the anal area is also much less.

Specific Relationships.—A comparison with the tabulated specific characters of all known European and American *Etoblattina*, shows that this specimen presents well-marked differences. From *E. manitoides*[1] it differs in the greater length of the mediastinal vein and its area, in the presence of four anal veins, and in the more simple unbranched character of the internomedian. The differences of shape, size, and character of the veins when contrasted with *E. Johnsoni*, Woodward (Geol. Mag., New Ser., 1887, Dec. III, Vol. IV, p. 53, Pl. II, Figs. 1*a–b*), are still greater. It will be sufficient to note that the mediastinal area is almost one-half less than in *E. Johnsoni*. *E. Deanensis*, Scd., shows a somewhat superficial resemblance, but in that species the wing is narrower, and possesses a somewhat pointed tip in place of the well-rounded margin shown in our specimen. The general courses of the mediastinal and scapular veins are much less curved; and the latter is regularly forked, which is not the case in this species. The specimen, on the other hand, agrees perfectly with Scudder's description of *E. propria* (op. cit.) in that the tegmina is less than twice as long as broad; the mediastinal area reaching nearly to the middle of the distal half of the tegmina; and the externomedian first forking beyond the middle of the wing.

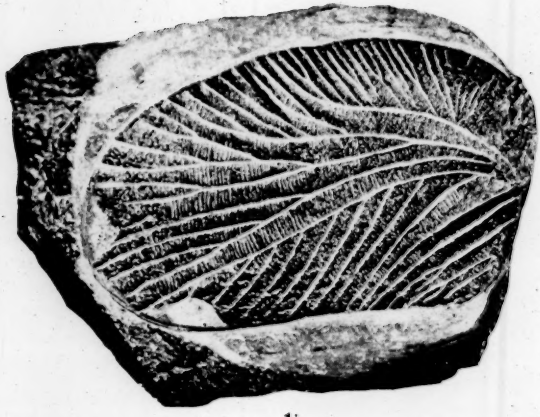
An examination, however, of Kliver's figure (*Palæontographica*, xxix, pl. v, taf. xxxv, fig. 3) shows that the mediastinal area is longer in *E. propria*, and that the veins in the latter pursue a much straighter course. The chief difference, however, lies in the character of the scapular vein. In *E. propria* the scapular vein gives off the externomedian, about 8 mm., above the base of the wing, whilst it is questionable whether these were ever united at all in the Welsh specimen. Unfortunately, the specimen is not sufficiently well preserved at the base to establish the point. Even had the two veins a common origin, the externomedian vein must have been given off from the scapular at the very base of the wing. It is, however, in the shorter mediastinal area, the forward curving of all the ultimate branches of the mediastinal and scapular veins, the more regular convexity of the anterior border, and the evident concave posterior or inner margin, that the chief differences consist, and constitute what may be regarded as specific identity. Further, Kliver's drawing shows no trace of 'cross-veins', which are so strongly marked upon the tegmina of our specimen, the interstices between the veins being filled instead with a close reticulation.

Handlirsch ("Revision of American Palæozoic Insects," Proc.

[1] Scudder, Mem. Boston Soc. Nat. Hist. Soc., 1879, vol. iii, pl. i, No. 3.



1a.



1b.

Photo by J. W. Tutcher.

Archimylacris (*Etoblattina*) *Woodwardi*, Bolton. South Wales Coal Field.

United States Nat. Mus., 1906, vol. xxix, pp. 661–820), who received the entire collection of Scudder's types in 1902, has since produced a monograph materially altering the relationships of many of the forms previously described, established a number of new genera, and revised previously existing ones. In the light of Handlirsch's conclusions, our specimen falls into the genus *Archimylacris* of Scudder, the type of which is *Archimylacris acadica*, Scd., with *Archimylacris* (*Etoblattina*) *venusta* as a nearly related species. I have much pleasure in naming the species *A. Woodwardi*, after Dr. Henry Woodward, to whom more than any other in this country palæontologists are indebted for their present knowledge of Palæozoic insects.

EXPLANATION OF PLATE XV.

Fig. 1*a*. Wing or tegmina of *Archimylacris* (*Etoblattina*) *Woodwardi*, Bolton. Nat. size; length 18 mm., width 10 mm. Photographed from the original specimen by Mr. J. W. Tutcher.

,, 1*b*. The same wing enlarged rather more than twice natural size.

The specimen was obtained by Mr. David Davies from a dark-blue shale (about 10 feet in thickness) overlying the No. 2 Rhondda Coal-seam in Clydach Vale.

III.—Some New Species of the Cirripede genus *Scalpellum* from British Cretaceous Rocks.

By Thomas H. Withers.

SINCE the publication of Charles Darwin's memorable monograph on the Fossil Lepadidæ (Palæontographical Society, 1851) little has been written on the British Cretaceous Cirripedes. Among the thirteen species of *Scalpellum* which Darwin figured and described, ten are British, and, so far as I am aware, only one, *Scalpellum attenuatum*,[1] has since been added to their number. Several species have, however, subsequently been described from Foreign Cretaceous Rocks.

During an examination of the collection of English Cretaceous Cirripedes in the British Museum (Natural History), I noticed several specimens which cannot be referred to any described species. They all belong to the genus *Scalpellum*, and by permission of the Keeper of the Geological Department, descriptions and figures are now given of them.

The work of comparison has been rendered easier by the identification, in the course of it, of several of the type-specimens figured and described by Darwin (1851). Some of these are referred to in the following pages.

Although I have followed Darwin and later authors in regarding certain characters as of specific value, I do not ignore the possibility that the forms here described as distinct species may eventually prove to be only stages or mutations in their development, and may perhaps connect forms already known. But not until all the existing material shall have been discriminated and recorded, and additional specimens are available from several horizons, will it be possible to apply

[1] H. Woodward, "Cirripedes from the Trimmingham Chalk and other localities in Norfolk": Geol. Mag., 1906, Dec. V, Vol. III, p. 352, Text-fig. 37.

Darwin's theory of evolution to the fossils which his study has rendered classical.

1. Scalpellum accumulatum, sp. nov. Figs. 1–4.

Diagnosis.—Carina narrow, moderately tapering, considerably bowed inwards, with inner margin much curved, not divided into parietes and intraparietes; apex pointed; basal margin rounded. Tectum very gently convex, almost flat, with obscure central ridge, marked off from the parietes by a well-developed ridge. Parietes narrow, less than half the width of the tectum, inflected, gently concave. Ornament: fine obtusely-angled V-shaped growth-lines continued over the parietes; near the basal margin are five ridges, similar in shape to the growth-lines, but irregularly spaced, strongly marked, and sharper on the parietes.

Fig. 1. *Scalpellum accumulatum*, T. H. Withers, sp. nov. External view of carina, × 2 nat. size. Aptian, upper part of Lower Greensand (Folkestone Beds): Folkestone, Kent. (B.M., I. 12,928.)
.. 2. Id. Side view, × 2 nat. size.
.. 3. Id. Transverse section at one-third from apex, × 2 nat. size.
.. 4. Id. Transverse section at one-third from base, × 2 nat. size.

Holotype.—A carina (B.M., I. 12,928) collected by Mr. F. H. Butler. The specimen, of which the basal margin is slightly broken, is in a matrix of very coarse-grained greensand. Extreme length 17 mm., breadth 4 mm.

Horizon and Locality.—Aptian, upper part of Lower Greensand (Folkestone Beds): Folkestone, Kent.

Comparison with other Species.—*Scalpellum simplex*, Darwin (1851, p. 39, pl. i, fig. 9), of which only a single carina is known, is the only species of the genus previously known from the Lower Greensand of the British Isles. It differs from *S. accumulatum* in having the parietes more inflected, set inwards, and not extending to the basal margin. Also in the much more convex transverse section of the carina, and the smooth surface. *S. accumulatum* may also be compared with *S. arcuatum*, Darwin (1851, p. 40, pl. i, fig. 7), from the Gault, and *S. trilineatum*, Darwin (1851, p. 38, pl. i, fig. 5), from the Grey Chalk, with both of which it agrees in the absence of a division into parietes and intraparietes. From *S. arcuatum* it is readily distinguished by the absence of the longitudinal ridges, and from *S. trilineatum* by the absence of the well-marked rounded central ridge, and the presence of the prominent V-shaped ridges near the

basal margin. The type of *S. trilineatum* (B.M., 38,461) was collected by W. Griffiths in the Grey Chalk (Cenomanian) of Dover. *S. accumulatum* also disagrees with *S. angustatum* (H. B. Geinitz)[1] from the Plänerkalk of Strehlen, Saxony, and *S. quadricarinatum* (A. Reuss)[2] from the Plänerkalk of Bohemia, in the absence of intraparietes. *S. quadricarinatum* further differs in the abrupt truncation of its basal margin.

2. Scalpellum comptum, sp. nov. Fig. 5.

Diagnosis.—General outline of tergum almost rhomboidal, ornamented with fine raised longitudinal ridges, some being finer than others. Apex pointed, but not sharply; basal angle probably rounded. Carinal margin forming an obtuse angle. Scutal margin sinuous, longer than the occludent margin, which is almost straight. A delicate furrow divides the valve unequally from the apex to the basal margin, the occludent portion being in its widest part about three times the width of the carinal portion. Carinal portion of valve ornamented with several fine raised longitudinal ridges, one of which is situated immediately at the side of the furrow, making the furrow more conspicuous. Occludent portion almost equally divided by a prominent raised ridge, somewhat coarser than the others, extending from the

Fig. 5. *Scalpellum comptum*, T. H. Withers, sp. nov. External view of left tergum, × 4 nat. size. Aptian, Lower Greensand: Sevenoaks, Kent. (B.M., I. 13,103.)

apex to the scutal margin. Between this ridge and the furrow the valve is ornamented with longitudinal ridges, which are finer and less elevated than those on the rest of the valve. The occludent margin has a raised border ornamented with several longitudinal ridges, similar in size to those on the carinal portion of the valve, followed by a wide groove, almost smooth, extending from the apex to the scutal margin, which is immediately bounded by the single longitudinal ridge. The growth-lines are more conspicuous on the occludent portion, where they are sinuous. This sinuosity is more marked between the single longitudinal ridge and the occludent margin.

[1] *Die Versteinerungen von Kieslingswalda*, etc., Dresden and Leipzig, 1843, p. 7, pl. iv, fig. 10.

[2] *Die Versteinerungen der Böhmischen Kreideformation*, Stuttgart, 1846, p. 105, pl. xliii, fig. 18.

Holotype.—Left tergum (B.M., I. 13,403), Caleb Evans Collection. Length of valve about 8 mm., breadth 4 mm., length of occludent margin about 5 mm., length of scutal margin 4 mm.

Horizon and Locality.—Aptian, Lower Greensand: Sevenoaks, Kent.

Another specimen, a right tergum (B.M., 13,404) from the same collection, locality, and horizon, undoubtedly belongs to this species.

Both terga have their basal angles broken, but judging from the adjoining outline of the margins there is little doubt that they were rounded. The left tergum is taken as the holotype, as it is the most perfect.

Comparison with other Species.—Under the name *Pollicipes radiatus*, J. de C. Sowerby (1836),[1] figured two valves of a Cirripede, which appear to be of different species. The only description given is: "Valves wedge-shaped, flat, marked with sharp, elevated rays, diverging from their apices." Darwin in his monograph (1851, p. 40) says of *Scalpellum arcuatum*: "This species appears to come nearest to *Pollicipes radiatus* of J. de C. Sowerby . . . but besides that that species comes from the Lower Greensand, the lower angle is much more pointed; the upper figure of the two appears to be something wholly different." Further, Darwin (1851, p. 80) says: "The *P. radiatus* of the same author (J. de C. Sowerby) of the Lower Greensand (pl. xi, fig. 6) is unknown to me; the tergum figured is like that of *S. arcuatum*; the upper figure, if a scutum, is very remarkable." As these two valves figured by J. de C. Sowerby apparently belong to different species, it seems advisable to fix the holotype, and I therefore select the upper figure as the type of *Pollicipes radiatus*. It may be that Sowerby's lower figure represents a valve of *S. comptum*, but since the specimen cannot now be traced, and the figure and description are quite insufficient for exact determination, it is advisable to establish a new species for the specimens mentioned above, and to place in it provisionally the original of Sowerby's lower figure.

S. comptum may be compared with the Albian *S. arcuatum*, Darwin (1851, p. 40, pl. i, fig. 7), from the Gault, and *S. fossula*, Darwin (1851, p. 24, pl. i, fig. 4), from the Senonian (*Bel. mucronata*-zone) of Norwich. Both agree with it in having a delicate furrow extending from the apex to the basal angle; *S. fossula* further agrees in having a slight longitudinal ridge dividing the occludent portion into two parts. This ridge, however, is not raised as in *S. comptum*. In *S. fossula* the surface is not ornamented with raised longitudinal ridges, but is almost smooth; the carinal portion of the valve is proportionately much narrower, the apex and the basal angle are much more pointed, and the scutal margin is not sinuous. *S. arcuatum* differs by the absence of the raised longitudinal ridge extending from the apex to the scutal margin, and by the lines of growth being much more sinuous on the occludent portion. The general outline is more

[1] Descriptive notes respecting the shells figured in pls. xi to xxiii, Appendix A, to W. H. Fitton, "Observations on some of the Strata between the Chalk and the Oxford Oolite in the South-East of England": Trans. Geol. Soc., ser. II, vol. iv, pl. xi, fig. 6.

oval, and the raised longitudinal ridges which occur nearly regularly over the entire valve give it a far different appearance.

3. Scalpellum cyphum, sp. nov. Figs. 6–9.

Diagnosis.—Carina narrow, moderately bowed inwards, with inner margin slightly curved, widening gradually from the apex, which is sharply pointed, divided into parietes and intraparietes; basal margin angular (about 75°). Tectum strongly arched transversely. Parietes narrow, steeply inclined from the tectum, slightly concave, about half the width of the tectum, widening gradually to the basal margin. Tectum and parietes ornamented with a number of coarse, rounded, longitudinal ridges, readily seen with the naked eye. One stronger ridge runs down the middle of the tectum, and one on each side divides the tectum from the parietes. The interspaces between the ridges are about three times the width of the ridges. Intraparietes separated from the parietes by a strong rounded ridge, measuring in their widest part slightly more than the rest of the valve at that part, widening rapidly from the apex and then narrowing rapidly until a little more than half-way down the valve, when they merge into the sides of the parietes, at a short distance from their basal margins. Surface of tectum and parietes covered with well-marked V-shaped growth-lines.

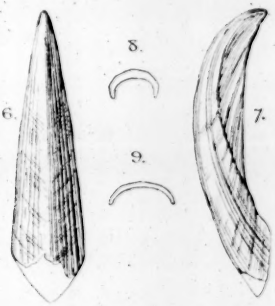


Fig. 6. *Scalpellum cyphum*, T. H. Withers, sp. nov. External view of carina, × 2 nat. size. Cenomanian, Grey Chalk: near Dover, Kent. (B.M., I. 13,405.)
,, 7. Id. Side view, × 2 nat. size.
,, 8. Id. Transverse section at one-third from apex, × 2 nat. size.
,, 9. Id. Transverse section at one-third from base, × 2 nat. size.

Holotype.—A carina (B.M., I. 13,405), J. Starkie Gardner Collection. Extreme length about 22 mm., greatest breadth 5 mm. The basal angle of the specimen is broken, but judging from one side of the margin it was probably angular.

Horizon and Locality.—Cenomanian, Grey Chalk: near Dover.

There is in the British Museum (Natural History), (B.M., I. 13,406), from the same horizon, locality, and collection, a smaller carina, which probably belongs to this species. It agrees in most of its characters with the preceding description, but the central longitudinal ridge is

more pronounced, and some of the remaining ridges on the tectum and parietes are more irregularly placed and a little less coarse.

Comparison with other Species.—The Albian *Scalpellum arcuatum*, Darwin (1851, p. 40, pl. i, fig. 7), a common Gault species, also has longitudinal ridges, which, however, are finer and confined to the tectum. *S. cyphum* is at once distinguished from that species by its greater transverse convexity and by the presence of intraparietes. It agrees in some of its characters with *S. aduncatum*, sp. nov. (see *infra*), but the far more numerous and much coarser longitudinal ridges give it an entirely different appearance. It is also more convex transversely, has less obliquely inclined parietes, more pointed apex, curved inner margin, and the ridge that separates the parietes from the intraparietes is much more strongly rounded and conspicuous.

4. Scalpellum aduncatum, sp. nov. Figs. 10–13.

Diagnosis.—Carina narrow, moderately bowed inwards, inner margin nearly straight, widening gradually from the apex, divided into parietes and intraparietes, apex very sharply pointed and a small portion of it probably projected freely, basal margin angular (about 75°). Tectum moderately arched transversely, ornamented with about ten sharply raised longitudinal ridges, all of which can be seen with the naked eye; one strong ridge runs down the middle, followed on each

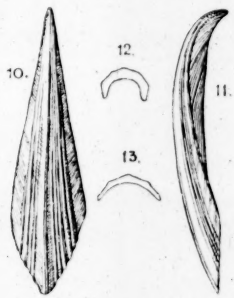


Fig. 10. *Scalpellum aduncatum*, T. H. Withers, sp. nov. External view of carina, × 2 nat. size. Cenomanian, upper part of *Holaster subglobosus*-zone: Oxted Lime Works, Oxted, Surrey. (B.M., I. 7235.)
,, 11. Id. Side view, × 2 nat. size.
,, 12. Id. Transverse section at one-third from apex, × 2 nat. size.
,, 13. Id. Transverse section at one-third from base, × 2 nat. size.

side by two or three finer ridges, which are bounded on either side by a pair of stronger ridges, close together, dividing the tectum from the parietes. Parietes narrow, obliquely inclined from the tectum, concave, about half the width of the tectum, widening slowly to the basal margin, and ornamented with extremely fine longitudinal striæ, which can only be seen with a lens. Intraparietes set a little inwards, separated from the parietes by a well-marked ridge, measuring in their widest part slightly more than the rest of the valve at that point, widening rapidly from the apex, and then narrowing rapidly until they reach little more than half the length of the valve, where they

merge into the sides of the parietes, some distance from their basal margins. Surface of tectum and parietes ornamented with very fine V-shaped lines of growth.

Holotype.—A carina (B.M., I. 7235), collected by C. P. Chatwin and T. H. Withers. Extreme length 19 mm., greatest breadth 4·5 mm.

Horizon and Locality.—Cenomanian, upper part of zone of *Holaster subglobosus*: Oxted Lime Works, Oxted,[1] Surrey.

Comparison with other Species.—This species is not unlike *Scalpellum lineatum*, Darwin (1851, p. 35, pl. ii, fig. 12), but in that species the sides of the tectum are steeply inclined towards each other, the parietes and intraparietes are only separated by a very slight ridge, the disposition of the longitudinal ridges is different, and the interspaces are ornamented with very fine hair-like lines. It may also be compared with *S. angustum* (Dixon), (1850, Geol. Sussex, pl. xxviii, fig. 9), and *S. hastatum*, Darwin (1851, p. 37, pl. ii, fig. 13), both of which were founded on single carinæ. It agrees with *S. angustum* in that the intraparietes only reach about half the length of the valve; but disagrees with it in that their bases are not abruptly truncated, but merge into the sides of the parietes. Further, the main ornament is formed, not by the V-shaped lines of growth, but by the longitudinal ridges. From *S. hastatum* it differs in that the valve is much less recurved, has shorter and wider intraparietes, and well-marked longitudinal ridges. The holotype of *S. hastatum* (B.M., 38,462) was collected by W. Griffiths in the Grey Chalk (Cenomanian) of Dover. Unfortunately, since Darwin figured it the apex has been broken off and lost.

5. Scalpellum lineatum, Darwin.

1851. C. Darwin, Pal. Soc. Monogr. Foss. Lepadidæ, p. 35, pl. ii, figs. 11, 12.
1877. H. Woodward, B.M. Cat. Foss. Crustacea, p. 142.

Darwin had for the description of this species, two carinæ, a scutum, and a tergum, but he assigned the two latter valves to the species only with doubt. Taking this into consideration, and since it is best that the type should be fixed, I here select the carina figured by Darwin (op. cit., pl. ii, fig. 12) as the holotype of *S. lineatum*.

One of the carinæ was in the collection of J. Sowerby, and the remaining carina and the scutum in the collection of J. Morris. All three valves came from the Lower Chalk of Sussex. Unfortunately I have been unable to discover what has become of them.

The tergum (B.M., I. 13,402) came from the Lower Chalk of Maidstone, Kent, and was formerly in the Bowerbank Collection.

6. Scalpellum dissimile, sp. nov. Fig. 14.

Diagnosis.—General outline of tergum rhomboidal; apex sharply pointed; basal angle pointed. Scutal margin straight, shorter than the occludent margin, about half the length of the valve. Carinal margin divided into two lines forming an obtuse angle, the upper portion shorter than the lower, and about the length of the scutal margin, the lower portion being about the length of the occludent

[1] Exposure noticed, G. E. Dibley, "Zonal Features of the Chalk Pits in the Rochester, Gravesend, and Croydon Areas": Proc. Geol. Assoc., 1900, vol. xvi, p. 492.

margin. Surface of valve ornamented with fine, almost regular, longitudinal ridges, rather close together, the interspaces about the width of the ridges. Running transversely to these, at regular intervals, are about sixteen folds or ridges, which probably correspond to the growth-lines. A prominent ridge extends in a straight line from the apex to the basal angle, dividing the valve into two unequal portions, the occludent portion being the broadest. This ridge on reaching about half the length of the valve bifurcates, but with a very narrow interspace; the ridge is very little thicker than those on the occludent portion, but it is prominent because the carinal portion of the valve lies on a lower plane than the rest of the valve, and the ridge on the carinal side has an almost perpendicular face. The longitudinal ridges, of which there are about eleven on the carinal portion, are flattened, the first two or three on the inside being bifurcated at their bases, and the interspaces very narrow. Those on the occludent portion, numbering thirteen, are sharply rounded, and more pronounced, the interspaces about the width of the ridges. From the apex to the scutal margin runs a faint groove, from which the occludent margin rises up.

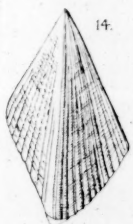


Fig. 14. *Scalpellum dissimile*, T. H. Withers, sp. nov. External view of left tergum, × 4 nat. size. Turonian, *Terebratulina*-zone; Gatchampton Farm, east of Goring-on-Thames, Oxon. (B.M., I. 8398.)

Holotype.—A left tergum (B.M., I. 8398), collected by C. P. Chatwin & T. H. Withers. The specimen has its basal angle slightly broken. Length of valve 7·5 mm., breadth 4 mm., length of occludent margin 5 mm., length of scutal margin 3·5 mm.

Horizon and Locality.—Turonian, upper part of *Terebratulina*-zone: Gatchampton Farm,[1] east of Goring-on-Thames, Oxon.

Comparison with other Species.—This tergum apparently agrees more closely with *S. attenuatum*, H. Woodward (1906, Geol. Mag., Dec. V, Vol. III, p. 352, Text-fig. 37) than any other species. The holotype of *S. attenuatum* is a tergum from the Senonian (*Bel. mucronata*-zone) of Harford Bridges Pit, near Norwich, and is in the collection of Dr. A. W. Rowe, who has kindly lent it to me for comparison. It is about three times the size of the holotype of *S. dissimile*. In *S. attenuatum* the longitudinal ridges, instead of being rounded and regular, are much flattened and vary in width on the occludent portion of the valve; the majority of those on the inner half are

[1] Description of section, C. P. Chatwin & T. H. Withers, "The Zones of the Chalk in the Thames Valley between Goring and Shiplake": Proc. Geol. Assoc., 1908, vol. xx, p. 394.

broad, while on the outer half they are mostly very fine. The carinal portion, instead of being ornamented with slightly flattened longitudinal ridges, has extremely fine longitudinal lines. It differs further in other characters, the most important being that the scutal margin is sinuous, while it is practically straight in *S. dissimile*. *S. dissimile* may also be compared with the tergum from the Cenomanian (Korytzaner Schichten) of Kamajk, Bohemia, represented in the figure given by J. Kafka[1] (1886), and assigned by him to *S. tuberculatum*, Darwin. This tergum agrees in having a number of raised longitudinal ridges radiating from the apex, but disagrees, among other characters, in that the valve is not conspicuously divided into two parts by a prominent ridge, and in the absence of a groove extending from the apex to the scutal margin.

In conclusion I wish to thank the following gentlemen for help in connexion with this paper: Dr. F. A. Bather, Mr. C. P. Chatwin, Dr. A. W. Rowe, and Mr. C. Davies Sherborn.

IV.—The Geology of the Dolgelley Gold-belt, North Wales.

By Arthur R. Andrew, M.Sc., F.G.S.

1. Introduction.
2. Previous Literature.
3. Stratigraphy.
4. Structure.
5. Petrology.
6. History and Statistics of Mining.
7. Lodes of the Dolgelley Gold-belt.
8. Summary of the Veins.
9. Genesis of the Auriferous Veins.
10. Bibliography.

Introduction.

THE town of Dolgelley lies slightly outside the main tract of gold-bearing country of Merionethshire, but it forms a convenient headquarters from which to visit the various gold-mines and auriferous lodes. The Dolgelley Gold-belt lies within the area covered by the quarter-sheets 27 N.E., 27 S.E., 32 S.E., 33 N.W., 33 N.E., 33 S.W., 36 N.W., 36 N.E. of the 6 inch Ordnance Survey maps of Merionethshire. It is on the north side of the estuary of the Mawddach, extending from the sea at Barmouth to the locality of Gwynfynydd on the north-east. The belt forms the south-eastern flank of a range of high ground sloping down to the south and south-east from the mountains of Rhinog, Diphwys, and Garn. It is drained by several tributaries of the Mawddach, of which the principal are the Afons Hirgwm, Cwm-llechen, Cwm-mynach, Wnion, Las, Gamlan, Eden, and Gain.

The rocks of the Gold-belt all belong to the Cambrian System, and are of two main lithological types—

(1) The greywacke set of the Harlech Grits of H.M. Geological Survey.

(2) The shale set of the Lingula Flags of H.M. Geological Survey: the lowest bed of the latter is usually separated out as a distinct zone, the Menevian.

Previous Literature.

A considerable amount of literature has accumulated, dealing with the stratigraphy, palæontology, petrology, mineralogy, and also the

[1] "Příspěvek ku poznání cirripedů českého útvaru křídového": Sitz. Ber. k. Böhm. Ges. Wiss., Prag, 1885, p. 565, pl. i, fig. 7.

mining of the district under review. A brief résumé of this literature will now be given, and a full list of references will be found at the end of this paper.

Stratigraphy.—The rocks of the district were first mentioned by Murchison (7) and Sedgwick (3), and formed part of the formations under dispute in the famous Cambro-Silurian controversy. Sedgwick's final classification was as follows, and in so far as it applied to the rocks of the Gold-belt it is that accepted to-day:—

3. Bala Group (Upper Cambrian).
2. Ffestiniog Group (Middle Cambrian) . . (*c*) Arenig Slates.
(*b*) Tremadoc Slates } which form
(*a*) Lingula Flags } the Dol-
1. Longmynd and Bangor Group (L. Cambrian . (*c*) Harlech Grits } gelley area.
(*b*) Llanberis Slates.
(*a*) Longmynd Slates.

Between 1850 and 1854 the whole of this Merioneth area was mapped by the officers of the Geological Survey, and in 1854 appeared their geological maps (on a scale of 1 mile to 1 inch): these have not yet been revised (11). In 1866 there appeared the first edition of the Geological Survey Memoir of the district (12). A new edition of this memoir, published in 1880 (13), contained some changes in the classification employed. The Tremadoc Slates were separated from the Lingula Flags, with which they had previously been associated, and at the same time the term Menevian was first used by the Survey, for the band of black shales and slates at the base of their former Lingula Flags. The sequence of the Survey became—

4. Tremadoc Slates . . . . . Upper Cambrian.
3. Lingula Flags . . . . . Upper Cambrian.
2. Menevian Slates . . . . . Middle Cambrian.
1. Cambrian Grits and Flags . . . . Lower Cambrian.

From 1846 to 1867 a certain amount of investigation was carried out, chiefly by Sharpe (16), Readwin (29), Salter (20), Plant and Williamson (23), Belt (24). Most of these investigations resulted in proposals of new classifications of the rocks, but on the whole these proposals have not been accepted. The chief of the investigators was Thomas Belt, who introduced the splitting of the Lingula Flags into the Dolgelley, Ffestiniog, and Maentwrog divisions—a grouping which is in use to-day. Belt's sequence consisted of—

10. Tremadoc Slates.
8 and 9. Upper and Lower Dolgelley.
7. Upper Ffestiniog: Tough blue-grey flags.
5 and 6. Lower Ffestiniog: Blue and brownish-grey fine-grained flags, the lower part slightly arenaceous and micaceous.
3 and 4. Upper Maentwrog: Dark-blue slates weathering rusty, the lower part yellowish and bluish-grey fine-grained flags, sometimes a little arenaceous, but not so coarse as the groups still lower.
1 and 2. Lower Maentwrog: Blue-grey and blue-black jointed slates with slightly arenaceous flags, the lower part grey, and yellowish-grey pyritic flags with hard felspathic bands.
0. Lower Cambrian, consisting of—
(*c*) Menevian with *Paradoxides*.
(*b*) Harlech Grits.
(*a*) Bangor Slates.

From 1867 to the present day, except the second edition of the Survey Memoir, 1881, nothing additional has been published.

Within the last ten years, however, Professor Lapworth and Dr. T. Stacey Wilson have mapped much of the Merionethshire country and determined the sequence and general distribution of the various lithological groups of the Lower Cambrian of the region. Although their work has not yet been published, they permitted me to use their results and showed me through their succession from the Cefn Slate Group to the top of the Vigra Beds. The following is the descending sequence of Lapworth and Wilson as employed and referred to by myself in the present paper:—

Lowest Lingula Flags of the Geological Survey.	9.	Ffestiniog Beds of Belt.
	8.	Pen Rhos Beds (Upper Maentwrog of Belt): Dark-blue slates characteristically weathering to a bright-red or perhaps rusty colour.
	7.	Vigra Beds (Lower Maentwrog of Belt): Dark-grey and blue slates, with numerous interstratified hard beds of felspathic and siliceous material, which occur throughout.
Menevian of Survey.	6.	Clogau Beds (Menevian of Salter and Belt): Black shales and slates.
Harlech Grits of Survey.	5.	Gamlan Shale Group: A succession of grey, greyish-green, and sometimes purple shales, slates, and flags, interbedded with occasional grit bands, which increase in number and thickness on going eastwards; thickness 750 to 1200 feet.
	4.	Barmouth Grits: Massive felspathic grits or greywackes with pebble bands; say 600 feet thick.
	3.	Hafotty or Manganese Shale Group (with the well-known persistent zone of manganese ore at the base): Grey and green shales and flags; to the west with rare grits; to the east the grits become more frequent and eventually coarse and thick-bedded; total thickness about 1000 feet.
	2.	Rhinog Grits: Massive grits forming the Rhinog and other mountains; thickness about 2500 feet.
	1.	Cefn or Llanbedr Slate Group: Blue and purple shales, flags, and slates; to the west (Egryn, Llanfair) with occasional grit bands; to east (Cefn Cam, etc.) the grits are more abundant, and the lowest beds (Dolwen) are red felspathic grits and shales.

Palæontology.—The district around Dolgelley had always been considered destitute of fossils until in 1864 Readwin found *Paradoxides Davidis*, which was described by Plant (22). This, together with the discovery of *Anopolenus* and *Theca*, enabled the lower beds in which they occur to be cut off from the higher beds in which are found the *Olenus* and *Lingula* of the Survey. In 1866 Plant discovered a considerable number of fossils (21–3). In 1867 Belt's examination led to the discovery and identification of many additional genera and species (24). Many fossils too had been discovered by the officers of H.M. Geological Survey. The following table contains the names of all fossils that have been discovered in the Dolgelley area and in the immediately neighbouring country. In this list 'P' means that the fossil was reported by Plant, 'B' by Belt, 'S' by the Survey.

From the Ffestiniog Group of Belt; the Hafod Owen of Plant.

B	*Conocoryphe micrura* (Salt.) (from Upper Ffestiniog).	B, P, S	*Lingulella Davisii* (McCoy).
P	*Conocoryphe* sp.	B	*Bellerophon cambrensis* (Belt) (from Upper Ffestiniog).
B, S	*Hymenocaris vermicauda* (Salt.).	P	*Buthotrepis* (?).
P	*Olenus* sp.		

From the Pen Rhos Beds; the Upper Maentwrog of Belt.

B	*Agnostus pisiformis* (Linn.).	B	*O. truncatus* (Angelin).
B	*Olenus cataractus* (Salt.).	S	*O.* sp.
S	*O. micrurus* (Salt.).	S	*Lingulella Davisii* (McCoy).

From the Vigra Beds; the Lower Maentwrog of Belt; the Cwm Eisen of Plant.

S	*Agnostus nodosus* (Belt).	S	*Hymenocaris vermicauda* (Salt.).
B	*A. pisiformis* (Linn.).	P, S	*Olenus cataractus* (Salt.).
P, S	*A. princeps* (Salt.).	S	*O. gibbosus* (Wahl.).
P	*A. trisectus* (Salt.).	P	*Sao hirsuta.*
P	*Holocephalina* sp.	S	*Lingulella Davisii* (McCoy).

From the Clogau Beds; the Menevian of Salter and Belt; the Tyddyn-Gwladys of Plant.

P	*Protospongia fenestrata* (Salt.).	P	*Leperditia* sp.
P	*Dictyonema* sp. (?).	P, S	*Microdiscus punctatus* (Salt.).
P	*Agnostus Davidis* (Salt.).	P	*Paradoxides Davidis* (Salt.).
P	*A. pisiformis* (Linn.).	P	*P. Forchhammeri* (Angelin).
P	*A. princeps* (Salt.).	P, S	*P. Hicksii* (Salt.).
P	*A. trisectus* (Salt.).	P	*Lingulella ferruginea* (Salt.).
P	*A. rex.*	P	*Obolella* sp.
P	*Anopolenus Henrici* (Salt.).	P	*Obolus* sp.
P	*A. Salteri* (Hicks).	P	*Theca corrugata* (Salt.).
S	*Conocoryphe* sp.		

Petrology and Mineralogy.—References to the petrology of the igneous rocks of the district will be found in the writings of Salter (20, p. 2), Forbes (25, 26, 27), and Teall (28).

A large number of minerals have been reported at various times from Merionethshire, chiefly by Readwin (30, 31), Forbes (25, p. 226; 27), and by Huddart (35). A list of these minerals is given below: unless otherwise indicated, the report of the occurrence of the mineral is to be found in one of Readwin's notices.

Native Elements: Gold, Electrum, Silver, Platinum, Platiniridium, Iridosmine, Copper, Lead (*Forbes*), Antimony, Bismuth.
Sulphides, Tellurides, etc.: Orpiment, Stibnite, Bismuthinite, Tetradymite, Galena, Sphalerite, Erubescite, Pyrrhotite (*Huddart*), Pyrites, Chalcopyrite, Marcasite, Arsenopyrite, Berthierite, Tetrahedrite, Aphthonite, Polytelite (*Forbes*).
Oxides: Quartz, Arsenolite, Senarmontite, Magnetite, Titanoferrite, Rutile.
Carbonates: Calcite, Dolomite (*Forbes*), Ankerite (*Forbes*), Chalybite (*Forbes*), Rhodochrosite, Cerussite, Malachite.
Silicates: Orthoclase, Hornblende, Uralite, Mica, Chlorite (*Forbes*), Ripidolite, Talc.
Phosphates: Pyromorphite, Mimetite.
Sulphates: Barytes (*Forbes*).

Mining.—In 1844 Dean (36) and Roberts (37) published the first notices relating to the discovery of gold in Merionethshire. During the years 1870 to 1880 Readwin published many articles in the *Mining Journal* and elsewhere, giving many details of the mining industry (32, 33). In 1902 Maclaren (38) brought together many interesting facts regarding the Merioneth field. Other references to the mining industry of Merionethshire are to be found in the writings of Forbes (25), Booth (39), Huddart (35).

Stratigraphy.

The divisions and groups which have been adopted in the present paper are those of Lapworth and Wilson for the Lower Cambrian and

those of Belt for the Upper Cambrian, as far as they have been generally accepted. The grouping therefore is—

	Tremadoc Slates	Upper Cambrian.
	Dolgelley Beds	
	Ffestiniog Beds	
Pen Rhos Beds	Maentwrog Beds	
Vigra Beds		
Clogau Slates	Menevian	Middle Cambrian.
Gamlan Shales	Harlech Grits	Lower Cambrian.
Barmouth Grits		
Manganese Shales		
Rhinog Grits		
Cefn Slates		

The order above is in the descending sequence of the beds. Of the formations enumerated, those which are more intimately connected with the occurrence of the auriferous lodes are the Gamlan, the Clogau, the Vigra, the Pen Rhos, and the Ffestiniog. These merit more detailed notice.

Gamlan Beds.—In the north-east part of the district, from the neighbourhood of the Afon Gain to near Blaen-y-cwm in the Wnion Valley, the lithological break between the Clogau and the Gamlan Beds is quite sudden, the black Clogau Slates extending down with all their usual characters to a basement grit (the Cefn Coch Grit), and the grey and grey-green beds of the Gamlan Group coming immediately below. In the western part, from Blaen-y-cwm to Barmouth, there is a more or less marked zone of transition, never more than 30 feet in thickness, in which there is an apparent commingling of the dark shales of the Clogau and the grey, green, and purple bands of the Gamlan. It would seem, therefore, that the grit disappears as such to the westward: almost everywhere, however, the boundary-line between the two types of Gamlan and Clogau Beds can be drawn fairly sharply.

In the north-east country the thickness of the Gamlan Group is 1200 feet, made up of intermingled grits, greywackes, flags, and shales. Following the outcrop of the rocks towards the south-west, the grits and greywackes become thinner and thinner, and the collective thickness of the beds less and less, until in the neighbourhood of the Afon Hirgwm most of the coarse-grained beds have disappeared, and the total thickness of the formation has become 750 feet. In this vicinity there is a grey flaggy bed near the top of the formation, characterized by the occurrence in it of good cubic crystals of pyrites, as much as half an inch along the edge. Traced further still to the south-west, the grits and greywackes become still finer, and near Barmouth the Gamlan Beds are seen to be made up entirely of shales and flags.

The Gamlan Shales contain numerous interbedded sills of greenstone. Towards the west, where the group consists chiefly of shales and flags, the sills are thinner than they are towards the north-east, where the greywackes are more frequent and massive. The massive greywackes would offer greater resistance to the folding forces, and would tend to form mighty buckles with large cavities between. The softer flags and shales would fold and pack more readily, and would not have

rigidity enough to support massive arches. The cavities formed would be smaller and less continuous, and this difference would be represented by the difference in the size of the greenstone sills that we see to-day.

Clogau Slates.—These consist of a thickness of 250 feet of well-cleaved slates, dark-blue and black in colour. The streak obtained by scratching, however, is never really black, and as the beds in many places are greyish blue it seems difficult to justify the epithets 'jet-black' and 'intensely black' applied by nearly all those who have previously referred to them. The slates weather to a dull crumbly ochreous yellow colour on the surface. Their dark internal colouring is due to organic matter and to iron sulphide, both being present in greater abundance than in the correspondingly black slates of the Pen Rhos Beds. On analysis I found that the Clogau Slates contained the following:—

Organic matter	5·78
Iron in the form of sulphide	21·88
Not determined	72·34
	100·00

The Clogau Slates do not give rise to surface features, and are seen to advantage only in the stream courses, especially in the bed of the Afon Gamlan, above its confluence with the River Mawddach. Further up the Mawddach, close to the Tyddyn-Gwladys mine, they cut across the river and are well exhibited. Other good localities are found in the course of the Bontddu stream from the St. David's Gold Mill to the Pont-ty-glan-afon; in the workings of the Clogau lode and on the Clogau Hill; and at Aber-Amffra Harbour close to Barmouth, where the beds are exposed on the roadside.

The Clogau Slates are interleaved with numerous thin pyritous bands, usually about $\frac{1}{8}$ inch in thickness, which are rarely discernible at outcrops on the hillside, but are quite plain in the stream-courses. When fresh these bands are but slightly paler in colour than the dark-blue slates with which they are bedded; but on weathering they turn white and show up very distinctly on the smooth water-worn beds of the streams. The cause of this peculiar weathering is probably the much greater proportion of pyrites contained in the white bands. On weathering, the pyrites sets free ferrous sulphate and sulphuric acid, and the latter may dissolve out some of the coloured constituents of the slate.

The Clogau Slates are interbanded with many sills of intrusive greenstone: a few of these are massive, ranging up to 100 feet in thickness, but the majority are much thinner, often as thin as 2 or 3 feet. The strike of the thinner sills is irregular: they show a tendency to cross a few of the planes of bedding, and then resume their original course.

Maentwrog Beds.—These lie above the Clogau Slates and have a thickness of about 2700 feet; they consist of dark-grey, dark-blue, and black slates and flags. There occur throughout them numerous bands of fine-grained siliceous grit. In the upper division of the Maentwrog Group, these are present only as thin wavy white layers,

from ¼ up to 2 inches thick. In the lower division, however, they increase in individual thickness to 2 or 3 feet, and occur as hard ribs sufficiently resistant to form surface features, and numerous enough to make up 25 per cent. of the actual thickness of the formation, as it is exposed in the Bontddu Glen and in the bed of the Mawddach River near the Cefn-deuddwr Gold Mine. The very great predominance of these ribs in the Lower Maentwrog is the lithological character which has been utilized by Lapworth and Wilson in separating the Maentwrog Beds into—

(*b*) Pen Rhos Beds or Upper Maentwrog.
(*a*) Vigra Beds or Lower Maentwrog.

(*a*) *Vigra Beds.*—The Vigra Beds are characterized by the large proportion of siliceous grit bands. In hand-specimens these grits are very fine-grained, homogeneous in texture, and light grey in colour; they resemble in appearance a fine-grained quartzite, and the similarity is increased by their extreme hardness.

Under the microscope it is seen that these bands are even and compact grits, the quartz grains of which are about $\frac{1}{300}$ inch in diameter. The visible minerals are quartz, muscovite, and a little felspar and pyrites. The grains of quartz are but slightly rounded, and a few may show crystalline faces: the quartz constitutes quite 95 per cent. of the total bulk of the rock. The microscopic structure of the flaggy beds in the Vigra Group is similar to that of the grit bands, but the flakes of muscovite are much more numerous and are arranged more or less parallel to the bedding.

The shales, slates, and flags with which the grit bands are interleaved are in the main similar in lithological characters to the slates, etc., in the overlying Pen Rhos Beds, but the harder ribs seem to a great extent to have protected the shales from cleavage, with the result that well-cleaved slates are seldom found. The colour of these interbedded shales and flags is dark grey and dark blue; the proportion of iron in them is somewhat less than in the Pen Rhos Beds, and the characteristic reddish weathering of the latter is generally wanting. Where exposed to atmospheric agencies the shales and flags weather easily from the outstanding grit bands. Many of the flaggy beds and a few of the grit bands weather more readily along certain lines which are not visible in the unweathered specimen, and the weathered surface becomes covered with curling ridges and furrows, which rather resemble tattooing. The type locality for these Vigra Beds is on Vigra Hill, which lies immediately north-west of Bontddu village. Good exposures are seen along the road which leads from Bontddu Post Office to the St. David's Gold Mill, and in the Bontddu stream parallel to this road. Other good exposures are in the bed of the Afon Cwm-Mynach above the Cambrian cottage, and in the bed of the Mawddach River upwards from its junction with the Afon-Eden.

(*b*) *Pen Rhos Beds.*—The Pen Rhos Beds are 1600 feet thick. They consist of shales and slates, always dark blue or black in colour; they are well cleaved, the cleavage usually being strong enough to efface the planes of bedding. They contain a few bands of siliceous grit,

but compared with the Vigra Beds these are very rare indeed. Owing to the relative softness of the Pen Rhos Beds they do not form prominent surface features, except where hardened by contact with igneous intrusions. The dark colour is due to finely disseminated organic matter and pyrites, the latter of which weathers to iron oxide and gives the slates a characteristic red coloration on exposed surfaces. On fresh specimens of the slates, cubes of pyrites may be seen up to half an inch in size. On analysis these slates gave me the following:—

Organic matter	3·90
Iron in the form of sulphide	12·48
Not determined	83·62
	100·00

The Pen Rhos Beds are best seen on the Pen Rhos Hill opposite the Tynygroes Inn, 5 miles up the Mawddach Valley from Dolgelley. Numerous sections are also exposed in the road cuttings along the turnpike road from Llanelltyd to within 2 miles of Barmouth.

Throughout the Maentwrog Group there are numerous igneous intrusions; these belong mostly to the so-called 'greenstone' of H.M. Survey, but some of them are hornblende porphyries. They are mostly sills, with a great extent in strike and dip, but never more than 100 feet in thickness.

Ffestiniog Group.—This group consists of over 3000 feet of grey and grey-green flags, with a few black shales and flags; they are hard and resistant and usually form fairly high ground. Among these grey and grey-green Ffestiniog Flags there are numerous harder ribs from 18 inches down to 1 inch and less in thickness. These are of two types: many of them are greywackes of medium grain; many are compact, fine-grained, and very siliceous grits, similar to those which constitute so large a proportion of the Vigra Beds described above. Where the shales and flags are dark-coloured they contain a large amount of iron, and their weathering causes the rock to assume reddish and dun colours. They are well seen along the road which runs past the mill of the Glasdir Copper Mine up the south bank of the Afon Las as far as Pont Llamyrewig. Good sections also occur in the workings and at the outcrops of the Glasdir Copper Mine, and the gold mine of Ffridd Goch. Many very massive igneous intrusions occur among the Lower Ffestiniog Beds, such as those forming the hills behind Penmaenpool, and also the heights of the Precipice Walk, Ffridd Goch, and Moel Cerniau.

Structure.

The Dolgelley Gold-belt lies on the east and south flanks of the well-known Harlech dome of Merionethshire. The great north and south sag between its two main arches, and which Lapworth and Wilson have followed from Moel Gedog, south of Talsarnau in a broken line through the Harlech uplands, continues into this country, and enters the Barmouth estuary close to the Caerdeon Vicarage. From the neighbourhood of Gwynfynydd southwards to near Llanelltyd the general strike of the beds is about 10° east of north. From

Llanelltyd westwards to Barmouth the general strike is in the main more north-easterly (45° or 50° east of north). This general flanking structure is much complicated by the minor folding to which the strata have been subjected. This folding has given rise to minor anticlines and synclines, often broken by small faults, especially along their axes, where, instead of yielding to the pressure by bending, the strata have snapped.

The faults found in this district may be divided for convenience into two classes—

(*a*) Minor faults or fractures.
(*b*) Major faults or throw faults.

The minor faults have probably been formed during the upheaval of the dome. They occur along those lines where the beds have been fractured, but where the pressure to which they have been subjected has not been sufficient to produce a relative displacement of the beds on the two sides of the fault. Among the harder beds of the Lower Cambrian they are especially numerous, crossing one another at all angles. In the beds of the Middle and Upper Cambrian they are not so frequent, as the strata there are not so massive, and have been more readily thrown into folds. Each of these fractures forms a noticeable groove along its outcrop.

Of the major faults or dislocations there are two main sets, with a third less important set—

1. East and west faults (practically 70° E. of N.).
2. North-east and south-west faults (30° E. of N.).
3. North and south faults.

1. *East and West Faults.*—These are almost certainly older than the others, for they are sometimes cut and dislocated by them. The most conspicuous one of this east and west set is the Cwm Mynach fault, which cuts out a great amount of the Lower Cambrian rocks. At its western end it is seen in the Maentwrog Beds; going eastwards it increases in throw, and on the Clogau Hill it cuts out fully one-half of the Gamlan Beds. As the fault is traced eastwards, it decreases in amount, and then disappears; it cannot be seen more than 5 miles away from its westerly extremity.

2. *North-east and South-west Faults.*—Instances of this set of faults are seen in the country behind Bontddu, but the displacement they cause is by no means large. They are probably contemporaneous with the north-east and south-west gold-lodes, for at Bwlchcochuchaf and Hafoduchaf there is a close relationship between one of these faults and the lodes which I describe later under these names. The north-east and south-west faults were formed after the east and west ones, as is seen in the country behind Bontddu.

3. *North and South Faults.*—These are the most recent and conspicuous of the faults of the Dolgelley Gold-belt. They are found throughout the district, but are of greatest importance towards the north-east. The chief faults of this set are the following:—

(*a*) The Llynbodlyn fault of Lapworth and Wilson extends from the estuary at Caerdeon to Llynbodlyn on the west of Diphwys, a distance of about 4 miles. It cuts several lodes and causes a considerable displacement of the sedimentary beds.

(*b*) The Bryntirion fault is about 2 miles long: it attains its maximum importance on the Clogau Hill, where it intersects the Clogau or St. David's lode.

(*c*) The Afon Gain fault runs along the course of the Afon Gain, and extends north and south from there. Its effect is greatest in the north, and it dies away to the south in the Maentwrog Beds, faulting the Gwynfynydd lode on the way.

(*d*) The Beddycoedwr fault passes down the east side of Moel Gwynfynydd. Like its companion, the previous one, it decreases in intensity towards the south, dying out finally in the Ffestiniog Beds. It cuts out all the Pen Rhos Beds, and a small part of the Vigra Beds. The eastern end of the Gwynfynydd lode terminates against it.

Cleavage.—All the finer-grained members of the sedimentary formations of this Dolgelley Gold-belt are traversed by cleavage planes. In very few cases, however, are the resultant slates of sufficiently good quality to be utilized for roofing or similar purposes. The strike of the cleavage planes is northerly; it usually lies between the limits of 5° west and 10° east of the meridian; it exceeds these limits very rarely. The dip of the cleavage planes is always steep, from 70° to 90°, sometimes towards the east, sometimes towards the west. The direction of cleavage in the gold-belt is entirely independent of the geological structure, as expressed in the dip and strike of the beds as a whole, and also of the minor puckerings and contortions into which the slates have at times been thrown. It is quite possible that there has been movement of the country subsequent to the development of the cleavage, but it cannot have been of great importance.

The movement of the country which gave rise to the cleavage must have been subsequent to the intrusion of the greenstone masses. In several instances we find examples in which a coarse, rude cleavage has been induced in the igneous rocks themselves, in the greenstone above the Precipice Walk, Dolgelley, and further east towards Llanfachreth. Other instances may be seen near the top of Y Garn and elsewhere. In these cases of cleaved greenstone, the direction of cleavage is the same as that of the finer general cleavage which traverses the slates. I have met with one case where the greenstone intrusion has an included band of shale hardened to such an extent that it had resisted the cleaving force and has remained uncleaved. It is possible that it may have been more or less protected by the great thickness of igneous rock in which it is enveloped, but the conclusion remains the same—that the greenstone was there before the cleavage commenced. This example is seen on the Clogau Hill, north of Bontddu, just where the old mine tramway crosses the large sill which runs from Llechfraithisaf up to the top level of the St. David's Gold Mine.

Although the intrusion of the greenstone is previous to the cleavage of the country, I believe that it is subsequent to the folding. In several cases where the rocks are puckered and folded, it is seen that the greenstone sills do not continue uninterruptedly round the folds, but feather out at the actual bend of the folds, the form of the intrusion being here determined by the pre-existing form of the folding.

Again, the intrusion of the greenstone appears to be subsequent to the movement of the country which caused the formation of joint-planes. Some distance up the Bontddu stream, 200 yards above the St. David's Gold Mill, a sill of greenstone is seen to end abruptly at a joint; there is absolutely no trace of movement having taken place along this joint-plane, and of the sill being faulted off. It therefore seems that the joint-plane was there before the greenstone was intruded, and was the determining factor in its abrupt termination.

The general sequence of events in this district after deposition thus appears to have been—(1) folding and jointing, (2) intrusion of igneous rocks, (3) cleavage. In this district there is no evidence to show the actual geological date of origin of these separate phenomena. In the North Wales region generally, however, it is considered certain that the cleavage of the region was effected in the interval between Silurian and Carboniferous times. In the North Wales region, the igneous rocks found among the Ordovician beds are believed to have been intruded in late Ordovician or Silurian times, and the greenstones of the Dolgelley Gold-belt were probably intruded at this time also.

According to Ramsay, the sequence of the movements in North Wales generally was—(1) intrusion, (2) folding, (3) cleavage. I think, however, that in the Dolgelley area the folding preceded the intrusion of the sills, but the point is not of great importance, as it is most probable that the two phenomena were closely associated, and took place at very nearly the same period.

Petrology.

Throughout the district in which the gold-bearing lodes of the Dolgelley Gold-belt occur, there are many intrusions of igneous rock, several of them of considerable magnitude. These intrusions occur in the form of dykes, of sills, and of more massive bosses. Dykes are by no means common and the only clearly defined examples occur in the country at the back of Bontddu. The sills are found most frequently among the soft yielding shales. In the softest formation of all, the Clogau or Menevian, they are very numerous, and have such a considerable aggregate thickness that in places they 'fatten out' the Clogau Beds by fully 50 per cent. The sills constitute far and away the greatest proportion of the igneous rocks of the district; they range in thickness from tiny interbeddings 6 inches wide, such as occur a short distance below the Vigra bridge, Bontddu, up to massive, almost laccolitic intrusions, 200 feet thick, such as form the conspicuous ridge at Llechfraith on the Clogau Hill. The sills continue quite evenly between the bedding planes for considerable distances before they die out. At times, however, they break across the bedding, and their intrusive and subsequent nature is thus clearly demonstrated.

The metamorphic effect of these igneous intrusions upon the rocks with which they come in contact is not very considerable. The shales are baked into hard porcellanites, but only for a short distance (a maximum of a few feet) from the intrusions. On weathering, these

baked shales project from the softer unchanged shales, and also as a rule from the intrusive rocks themselves. The black shales are to a certain extent decolorized by the baking.

I believe that in this district the igneous rocks all belong practically to the same period. There is no great diversity of lithological character among them, and they probably originated in the same common magma. The petrographical character of the igneous rocks is difficult to determine, the metamorphic action to which the rocks have been subjected has been sufficient to destroy and change the characters of many of the minerals of which they are composed. There are two types of igneous rock represented in the district: (1) Diabase (of Harker, Teall, etc.); (2) Porphyry (of Rosenbusch).

Among the diabases are practically all the 'greenstones' of H.M. Geological Survey. (The name 'greenstone' is so convenient for referring to the diabases that I have used it almost invariably throughout this paper.) The structure of the rock is intermediate between the plutonic and the volcanic types, though there is considerable variation and gradation in structure. The minerals that occur in the rock are oligoclase, hornblende, uralite, pyrrhotite, pyrites, chalcopyrite, calcite, sericite, kaolin, and iron oxides. Plagioclase forms the most conspicuous phenocrysts in the rock; the crystals, rounded in outline, are twinned—chiefly albite twins; the plagioclase is probably a basic oligoclase close to andesine; the felspar phenocrysts are always cloudy, the cloudiness being due to the presence in them of weathering products such as calcite, kaolin, etc., the individuals of felspar range down in size to minute lath-shaped crystals, which make up a large proportion of the ground-mass of the rock. Hornblende is seldom seen to satisfaction, it occurs among the phenocrysts, where it is intensely brown and strongly pleochroic; usually the hornblende is completely decomposed into sericite and chlorite. Pyrites, pyrrhotite, and chalcopyrite are very abundant in the rock, but as far as my examination goes, there is no evidence to determine whether these minerals were originally present in the rock or have been subsequently introduced. Chlorite, sericite, kaolin, and iron oxides are found among the decomposition products of felspar and hornblende, but their characters call for no special mention. The specific gravity of this diabase rock is 2·84; it should be noted that the felspar is oligoclase, which is rather too acid a type of plagioclase to be usually found in a diabase.

The second type of the igneous rocks of this Gold-belt is a porphyry or uralite porphyry; it is of much more restricted occurrence than the diabase, and I know of only two outcrops where fresh specimens may be obtained; these are at Y Garn and at Cefn-deuddwr. The Y Garn rock is typically porphyritic, the phenocrysts consisting of orthoclase, uralite, and hornblende, the latter much decomposed; the ground-mass is fine-grained and microcrystalline, and is densely packed with little squares of orthoclase, which, like the phenocrysts, present only the usual characters. The only other minerals in the rock are muscovite, chlorite, and pyrites, produced by the decomposition of the hornblende; the specific gravity of the rock is 2·738.

The Cefn-deuddwr rock differs from that occurring on Y Garn in

the much greater size and abundance of the phenocrysts of uralite, hornblende, and orthoclase, and in its coarser texture; the individuals may be as much as 1 inch in length. The rock is composed of orthoclase, plagioclase, hornblende, uralite, chlorite, magnetite, calcite, and pyrites. Orthoclase is found in large amount both in phenocrysts and in the ground-mass. In the former it often shows a clearly marked arrangement of concentric zones on the external margin of the crystal; the orthoclase is usually cloudy, owing to the presence of calcite. Plagioclase is present sometimes, but never to such an extent as the orthoclase; it is confined to the ground-mass, where it occurs as lath-shaped albite twins, probably andesine. Hornblende, like the orthoclase, occurs in two generations, among the phenocrysts and in the ground-mass; it is brown and strongly pleochroic. The bulk of the coloured constituent of the rock is uralite. Magnetite is a decomposition product of the hornblende, occurring along the cleavage cracks of the smaller hornblende crystals and giving a lattice-like appearance to the mineral. Pyrites may at times be very abundant in the rock, but often it is quite absent: it is perhaps of secondary origin.

It is to be noted that Forbes in 1868 (27) reported and described a uralite porphyry from this neighbourhood.

(*To be continued in our next Number.*)

V.—On Coral Zones in the Carboniferous Limestone.

By R. G. Carruthers.[1]

Amongst the corals collected by the Geological Survey during the past season, and submitted to me for determination, two specimens call for special remark, since they appear at first sight to occur out of their true zonal position. They were found by Mr. Dixon on the Pembrokeshire coast, to the south and south-west of Castle Martin. In each case Mr. Dixon gives the horizon as C_2–S_1, in the terms of Dr. Vaughan's classification. They are, accordingly, of Lower Visean age.

One of the specimens (E.D. 1253) is referable to the genus *Dibunophyllum*. In cross section there is a general resemblance to the figure of *Dib.* aff. *γ* recently given by Mr. Douglas.[2] In the Pembrokeshire specimen, however, the mesial plate, although conspicuous, is not thickened in the middle, and the central area is more clearly separated from the septa. In vertical section the central and tabular areas are sharply differentiated, the former being crowded with fine vesicles directed inwards and upwards at a steep angle.

The second specimen (E.D. 1350) is an example of *Cyathaxonia rushiana*, Vaugh. A cross section shows the characteristic columella, relatively large, oval, and with a 'lath' in the centre.

Hitherto, *Dibunophyllum* has not been recorded in the British Isles below the *Dibunophyllum* zone (D), while *Cyathaxonia rushiana* has only been found at a still higher horizon in the uppermost Visean,

[1] Communicated by permission of the Director of the Geological Survey.

[2] J. A. Douglas, "The Carboniferous Limestone of County Clare": Q.J.G.S., 1909, vol. lxv, pl. xxvii, fig. 6.

i.e. in the *Cyathaxonia* or D_3 sub-zone. It must be remembered, however, that *C. rushiana* shows a close approximation to the well-known Tournaisian coral *C. cornu*, Mich., and that the *Dibunophylla* are not widely differentiated from many of the Clisiophyllids found in Lower Visean, Upper Tournaisian, and Upper Devonian beds.

The discovery of these two fossils at a Lower Visean horizon adds another link to a chain of evidence bearing on the nature of the zones adopted for the Carboniferous Limestone. Facts have now accumulated in sufficient number to warrant a brief discussion of the value of these zones as time indices. In this respect, without wishing to criticize unduly a zonal system whose application to stratigraphical problems has met with much success, it is nevertheless desirable that the limitations of the system should be pointed out.

So far as the corals are concerned, it must be said that the zones are not based upon the presence of forms which are in true genetic sequence so much as upon a succession of unrelated faunal phases. They are, in fact, dependent upon a series of physical conditions (not of necessity expressed lithologically), each of which is favourable to certain gentes only. Almost invariably a gens flourishing at one particular level is not found in the beds immediately above or below, but reappears after a considerable interval in a more or less modified form. Abundant illustrations of such a fact are supplied by the distribution of the corals in the South-Western and Midland Provinces. Thus it is found that the gens of *Cleistopora geometrica* disappears entirely above the *K* zone, unless it recurs at the top of the Visean under the guise of *Paleacis cyclostoma*. Again, the gentes of *Zaphrentis delanouei* in Z_1, and of *Z. omaliusi*, *Caninia cornucopiæ*, and *Cyathaxonia cornu* in Z_2, γ, and C, are not again found above those zones until the highest Visean beds are reached. They then reappear in the D_3 or *Cyathaxonia* sub-zone in a series of mutational forms (in Waagen's sense), whose difference from the parent stock is not great, considering the interval of time that has elapsed.

The sudden and abundant appearance of *Caninia gigantea* in γ, of *Lithostrotion junceum*, *Lonsdaleia floriformis*, and many other members of the rich Upper Visean fauna, also cannot be accounted for by any observed genetic connexion with immediate predecessors, but must probably be ascribed to immigration. It cannot be said that ancestors of these forms have been found in the preceding zones, although in all probability they are present in the Clisiophyllids and the simple and compound *Cyathophylla* of the Upper Devonian. Many other instances of a similar nature might be given, but their enumeration is scarcely necessary for our present purpose.

The explanation of these phenomena seems to lie in an application of the old theory of 'colonies', the various gentes having lived in outlying areas until conditions favourable to their existence recurred. It is not for a moment to be denied that over a very large area, embracing the South-West of England, North and South Wales, the Midlands, and even the West of Ireland and Belgium, the sequence of physical conditions, and consequently of fossils, is usually in the same order. Sooner or later, however, local areas are met with where different conditions have prevailed. Consequently there is an

abnormal faunal phase, and difficulties of correlation immediately arise. That is instanced in the lower part of the Rush sequence, and in the attempt to trace the subdivisions of the uppermost Visean, established in the Midland Province and in the Loughshinny coast section, through the totally different facies obtaining in the North of England and Scotland.

The objection, therefore, to a rigid stratigraphical application of those corals now regarded as of zonal value, is that the present system is dependent on the succession of a number of forms, most of which are not in genetic connexion, and of whose true range in time we have at present little or no conception. It must be self-evident that it is impossible to estimate the time value of any fossil until the evolution of the gens to which it belongs has been worked out, and the range of the various mutations ascertained. A system of zoning established on such lines may seem an impossible ideal, but it is certainly attainable in some degree. In the meantime Dr. Vaughan and his co-workers have, as a rule, utilized the general characters of the faunal assemblage as diagnostic of any particular horizon. The errors caused by the introduction of species, by favourable conditions, at a somewhat different level in the areas concerned, are in this way made partially to counterbalance each other. If, in addition, the sequence of physical conditions, and therefore of faunal phases, are in agreement, then reliance can be placed on the broader aspects of the correlations suggested. It is in this way that the unconformity within the Limestone in South Wales, and the extensive overlaps in North Wales and Yorkshire, have been demonstrated. But the fact remains that the finer details of correlation must be open to question so long as a zonal scale has to be used in which the genetic sequence is so imperfect. That is so even in areas exhibiting a similar succession of physical conditions. Even more objection applies to precise correlations based on the sudden appearance of certain gentes that are not represented in underlying beds. And it is still more doubtful whether correlations, except of the most generalized kind, can be made by existing methods, between areas exhibiting a serious difference in faunal facies. In such cases, it would seem that reliable results can best be attained by working out the evolution either of the few gentes common to both areas, or of the contrasted gentes, if they can be found together in another region. In the meantime, it is by the discovery of intermediate links, such as the two interesting corals found by Mr. Dixon in South Wales, that a zonal scale, of a continuously genetic nature, may eventually be established. The frequent discovery of such fossils need cause no surprise; on the contrary, it is only to be expected during the progress of research.

VI.—On the Occurrence of Aragonite in the Middle Lias of Leicestershire; with some remarks on the calcareous character of the *Spinatus* beds.

By A. R. Horwood (Leicester Museum).

THE Liassic strata generally are so barren of any minerals of importance or of an appreciable size or extent that the record of the discovery of one not hitherto known to occur in a crystalline

form, apart from the part it plays in the formation of shell-layers at that horizon, is assuredly of interest. Hitherto the Liassic strata have not yielded any minerals unassociated with shell-structure, except selenite, which occurs commonly in some Upper Liassic clays, whilst it is not unusual to find fossils converted into iron-pyrites or marcasite, especially at certain horizons. The Doggers of Yorkshire are noteworthy instances of this kind. In the Middle Lias, zinc, nickel, and cobalt are found in the iron-ores of the Cleveland district.[1]

Whilst confined hitherto, so far as I am aware, to the parts of shells, etc., which have not been converted into calcite—the usual form taken by carbonate of lime when replacing the lime secretions of shells of Mollusca and other testaceous animals—aragonite has now been discovered by the writer unassociated with organic remains in the *Amaltheus spinatus* beds of the Middle Lias, or Rock-bed, at Tilton Hill, near Lowesby Station, Leicestershire.

The mineral exhibits clearly the acute pyramids characteristic of it, with orthorhombic crystals. Although not common it forms a mass about a foot square in some places the crystals being radially arranged, as is usually the case, with their terminations all directed to a common centre, in much the same way as those of quartz in the 'potato-stones' or geodes of the Trias. But their mode of occurrence seems best compared with certain boulders of strontia, discovered by Mr. H. Bolton[2] at Leigh Court, near Bristol, the outer surface presenting an amorphous rounded exterior, characteristic of worn boulders in general.

The surface of the Tilton boulders does not, like the Triassic boulders, present grooves. I was informed by Mr. G. W. Lamplugh that the Middle Lias at Barnstone presents striæ, but these are probably not of Marlstone age, but truly Glacial (or post-Pleistocene). It is interesting to note that in typical aragonite a small percentage of strontia (4 per cent.) usually occurs. The exact horizon of these deposits at Tilton Hill is a few feet at most, usually a few inches, above the thick "encrinital limestone band", which occupies so constant a position, just below the Transition-bed, between the Middle Lias (*spinatus*-beds) and the Upper Lias. This horizon is a well-marked one, and may be traced all over the higher ground at Tilton Hill. The name "encrinital limestone band",[3] adopted from Wilson,[4] is not quite correct, since encrinites do not enter into its composition, but, as pointed out elsewhere,[5] this band is made up of joints and portions of stems of Crinoids, with fragments of *Pecten*, Polyzoa, and other littoral organisms, resembling in composition some forest marbles of the Eastern Counties, as suggested to me by Professor T. R. Jones. Perhaps a better name, more correct from a palæontological point of view, is *crinoidal limestone band*. The crinoid stems, though fragmentary, are abundant, and the horizon

[1] *Vide* Rudler, "Minerals of the British Isles": Mem. Geol. Surv., 1905, p. 191.

[2] See Geol. Mag., 1907, p. 471. These boulders varied in size from that of a pea to that of a mass 100 tons in weight.

[3] Geol. Mag., 1907, pp. 462–3.

[4] Ibid., 1886, p. 296 et seqq.

[5] Trans. Northants Nat. Hist. Soc., 1907, p. 105.

forms a distinct band in section, being highly calcareous, and in character a crystalline limestone, consisting of at least 60 per cent. of carbonate of lime. From its composition it is thus practically pure calcite. Indeed, the organic contents are mainly calcite, and the inorganic residue consists of a small percentage of lime, with iron and a little detrital matter, though in this last respect it varies a good deal.

Dr. R. Brauns[1] has pointed out that calcareous deposits may be determined in their ultimate character by the temperature of the solutions from which they are precipitated, calcite being formed with its characteristic rhombohedra in a cold solution, or one in which there is a preponderance of alkaline silicates, whilst a warm solution, and one in which gypsum or strontianite occurs, is conducive to the formation of aragonite. The amount of concentration of the solution influences the direction which the carbonate of lime will take, or its ultimate form as calcite or aragonite. Thus Credner[2] has found that a cold saturated solution produces calcite, a warm dilute solution aragonite. These conclusions are borne out, moreover, by the physical relationship between the contents of this crinoidal limestone and the strata above. Thus above this horizon the beds are more ferruginous, less calcareous, often glauconitic, and of a distinctly more littoral type, the chief characteristics of the fauna being Gasteropods, Echinoderms, and Cephalopods. These beds would thus present, when unconsolidated and in a state of solution, a warmer temperature, and because they were further from the bottom of the basin or floor of the sea would be less concentrated with calcareous matter, but would contain more alkaline silicates. Thus aragonite would here replace the carbonate of lime, which does not amount to as much as 50 per cent. And this is what is actually the case, the shells being aragonite shells, though not confined to the zone or organisms mentioned and more constant at the horizon indicated. Cephalopods, *Pinna*, *Amusium*, and others all have the outer original aragonite layer removed, and are preserved as casts, with few exceptions. In the iron-ore beds the percentage of lime is 62·14 per cent., with ferric oxide 25·71 per cent. at Caythorpe and 30 to 33 per cent. at Tilton.[3] But here and elsewhere the percentage of lime generally in the ore-bearing rock is very much lower, being about 13 per cent., whilst there is 29 per cent. of carbonic acid. In the crinoidal limestone band, however, the constituents are markedly different. Of lime there is a percentage of quite 60 per cent., and an absence of detrital matter or ferric oxide to an appreciable extent. This band, moreover, marks, as I have suggested, the culmination of pelagic and the inset of more littoral conditions. In this way it would naturally have been deposited as a more or less concentrated solution, because nearer the bottom into which all saline matter collects, and a colder solution from its abyssal character. Moreover, pure limestone usually denotes deposition far from land, and in this case the pure character may be due to absence of sandy or argillaceous matter and undisturbed deposition of lime, whilst the

[1] *Chemische Mineralogie*, 1896, p. 156.
[2] *Neues Jahrb.*, 1871, p. 288.
[3] Geol. Mag., 1907, pp. 462–3.

fragmentary character of the organisms may denote that the deposit, which is very thin but constant, owes its highly calcareous nature to its being an ancient sea-floor. The fragments are not rolled, but are broken portions that have dropped down into the abyssal depths from the higher zones. It seems, indeed, more natural to regard it as at first pelagic and gradually elevated, allowing of more littoral conditions above.

The occurrence of calcite and aragonite in the same seam, which is found in most instances to be the case where an abundant fauna occurs, is quite in harmony with known conditions elsewhere, for in the hæmatite deposits at Cleator Moor both calcite and aragonite occur.

It may be of interest here to note the distribution of calcite and aragonite when replacing carbonate of lime of shells of Mollusca or other animals. Dr. Sorby[1] has shown that the shells of some organisms are preserved as calcite, others as aragonite, whilst in some one portion is converted into calcite, the other into aragonite. And he demonstrated that certain forms—Foraminifera, Annelids, Echinoderms, Polyzoa, Brachiopoda, *Ostrea*, and *Pecten*—when preserved as fossils have their shells converted into calcite, whilst in Corals, Cephalopods, Gasteropods (except *Patella*, *Fusus*, *Littorina*, *Purpura*, etc.), Lamellibranchs (except *Ostrea*, *Pecten*, and the outer layer of *Spondylus*, *Pinna*, and *Mytilus*) the shell-layer is preserved as aragonite, if not removed by decomposition. Thus the shells and other parts of organisms from the base of the Middle Lias up to the crinoidal limestone band may be said to be largely preserved in calcite, e.g. *Ditrypa*, *Rhynchonella*, *Terebratula*, *Pecten*, and *Ostrea*, whilst *Cerithium*, *Phasianella*, *Amaltheus spinatus*, *Tropidoceras acutum*, etc., above are preserved in aragonite. Likewise *Eodiadema granulatum*, found above the crinoidal limestone band, when the test is present, is preserved in calcite, as are all the fragments of Polyzoa, *Pentacrinus*, etc., in the latter.[2]

In regard to the general character of the shell-layer in deposits of Liassic age generally, Sorby wrote:[3] "On the whole, the organic constituents of the coarser-grained beds of the Lias are closely like those of similar beds of Oolitic age, though there is a relatively less amount of fragments of aragonite shells and corals. By far the greater bulk is made up of joints of *Pentacrinus*, which in some cases constitute nearly the whole rock. Next in abundance are fragments of Brachiopods and oysters and shell-prisms; but Foraminifera and portions of Belemnites and bone also occur." Further he says: "Occasionally very crystalline, non-radiate, oolitic grains are met with, which have all the characters of re-crystallized, small, concentric, aragonite concretions."

[1] Quart. Journ. Geol. Soc., 1879, vol. xxxv, pp. 63 et seqq.

[2] See also P. F. Kendall, Geol. Mag., 1883, pp. 497 et seqq., for a further list of forms preserved in calcite and aragonite respectively in the Coralline Crag. His researches bear out in a remarkable way, as to that formation at least, those of Sorby, whilst in so far as my own observation has gone I am able to corroborate his conclusions in the case of the Middle Lias (*vide supra*).

[3] Ibid., p. 84.

The very hard character of the crinoidal limestone band, made up so largely of crinoid stems, is due to the preservation of the constituents as calcite. And it is doubtless to a similar horizon that Dr. Sorby refers above, though there is no reason for assigning them in particular to *Pentacrinus*. In a section this band stands out some distance from the beds above and below, protecting the latter from denudation. In the quarry at Billesdon Coplow the position of this band is well shown, being indicated by a marked projection near the top of the section. The section shows, moreover, the position of the Transition-bed, the horizon of *Eodiadema granulatum*, and many Gasteropods. The same band is the horizon of the aragonite boulders at Tilton Hill. The hardness of the crinoidal band is indicated by its fresh surface when transported in glacial deposits, whereas the ferruginous marlstone is generally decomposed and weathered. The oolitic grains mentioned by Sorby as consisting of aragonite concretions occur in small glauconitic pockets of the Transition-bed, and upon faces of the jointed rock. These concretions are similar in character to those found—if the deposits are of carbonate of lime—in hot-water boilers, though aragonite alone is not found. Aragonite in a crystalline mass may depend upon the distribution of water in rocks, or the water-level. Thus W. Wallace[1] found that it was only to be met with above the water-level in caverns in Cumberland. This is analogous to the distribution of aragonite as the replacing mineral in the shell-layer of fossil organisms. Messrs. Cornish & Kendall[2] found that shells in permeable strata had their aragonite layer dissolved out, whilst those protected by an impermeable layer above were preserved. To a less extent calcite is affected in the same way.

In the littoral sandy, ferruginous, and readily permeable beds of the Middle Lias Marlstone a large percentage of the aragonite shells have their shell-layer dissolved away. The aragonite boulders above the crinoidal limestone band are similarly worn externally, probably by the action of water through percolation. In the first instance they must have been precipitated in a warm solution, and consequently at a period when the surface was elevated above the level at which the crinoidal band itself was formed.

Aragonite is found in older calcareous rocks, chiefly Mountain Limestone or earlier rocks, in Cornwall, Devon, Dorset, Derby, Cumberland, Durham, and Somerset; in Scotland at Lead Hills, Galloway, Seafield, Portsoy (Banff), Shetland Islands, and Orkneys; and in Ireland in Antrim, Derry, Down, Kerry, and MacGilligan. To these localities must now be added Tilton Hill,[3] Leicestershire. The best localities are Alston Moor and Cleator Moor, where there are hæmatite deposits. As a whole it is thus characteristic of the older rocks, when doubtless the mean thermal heat was greater than in later geological times.

[1] Quart. Journ. Geol. Soc., 1865, vol. xxi, pp. 413–21.

[2] "On the Mineralogical Constitution of Calcareous Organisms": Geol. Mag., 1888, p. 66.

[3] Though so called this locality is close to Lowesby Station (G.N.R.), and must not be confounded with the cutting near Tilton Station (joint L.N.W.R. and G.N.R.), a locality more widely known than the Lowesby one.

But the opposite appears to be the case in regard to the shell-layer, i.e. of organisms preserved in part as carbonate of lime, for in their case aragonite shells, judging from the occurrence of casts, are more typical of later than earlier deposits. In this case we must remember that the habitat of the animal will influence the replacement of its shell as calcite or aragonite—in other words, their distribution depends in each epoch upon the bathymetrical range of the organisms. But that of the crystalline masses of aragonite found in caverns and cavities in other rocks depends, according to Wallace, upon the water-level and the temperature of springs percolating through the superincumbent mass, and in large measure upon the former secular heat of the earth's crust.

REVIEWS.

I.—The Face of the Earth (Das Antlitz der Erde). By Eduard Suess. Translated by Hertha B. C. Sollas, under the direction of W. J. Sollas. Vol. IV. 8vo; pp. viii, 673, with 55 illustrations. Oxford: Clarendon Press, 1909. Price 25*s.* net.

WITH this fourth volume, which brings the total number of pages up to 2233, we have the completion of the text of Professor Suess' great, and we may well say marvellous, work. To ascertain what is known of the main features in the structure of the entire globe, to systematize that knowledge, to show the influence of successive crust-movements on the present features of the earth's surface, is but a bald account of what has been accomplished by the author, and admirably rendered into English by Miss Hertha Sollas, with the aid of her father.

Knowledge based on the sedimentary characters and life-history of the formations, on the extent of land and sea areas at different epochs, and on the influence of volcanic phenomena is fully utilized; but the dominant feature in *The Face of the Earth* is the careful study of the earth-movements and foldings to which various districts from time to time have been subjected. Some areas, like Laurentia, show little or no disturbance since Cambrian times, the strata of that epoch lying horizontal, whereas other regions have been affected by more or less complex systems of folding at successive epochs, the movements being influenced by buttresses of older rocks that have led to deflexion and overthrusting.

In the present volume attention is drawn to the arc-like curves of mountain chains, and also to the arcuate lines to be found among the Pacific islands, where the greatest abyssal depths, having the form of elongated furrows, lie in front of the outer border of the arcs. As the author remarks: "With one or two exceptions, all marine abysses which sink below a depth of 7000 meters are fore-deeps in a tectonic sense, and indicate the subsidence of the foreland beneath the folded mountains. Thus we are brought back to the question, whether the greatest deeps, like the highest mountains, are not the most recent."

With respect to deep-sea accumulations it is remarked: "We may conceive that little calcareous shells sink to the bottom in great quantity. They are dissolved at great depths, but accumulate in moderate or lesser depths. In the abysses red clay is deposited only in trifling quantity, but on those submarine elevations which rise above the level at which carbonates are dissolved, accumulation occurs. The result is an exaggeration of the relief. Thus the depths persist, while the ridges increase in height, and may even grow into peaks." Moreover: "During a long period of rest not only may a great sockle of limestone arise, but at some remote period, when the level of the ocean was higher, the deposit of limestone may even have grown up to a height above the sea-level as it now exists. It has then been denuded in terraces owing to intermittent negative movement."

Concerning the views of Darwin and Dana on atolls the author observes: "It must still be admitted that the depth of the enclosed lagoon has not yet been completely explained. Thus, the view that the crown has been built up by corals during positive movement has still some foundation."

With regard to the great African fractures it is remarked: "We must not form too rigid a conception of such troughs, as though they were strips of land let down between two parallel faults. Step faults are to be seen on Lake Tanganyika and in the lava fields which lie before Mount Kenya, on the west coast of the Red Sea also, and more to the north on Mount Lebanon and the slopes of the Jebel Ansarieh. We shall form a more correct picture if we think of these step faults as repeated on both sides, down to the middle of the valley bottom—many long strips, which become wedge-shaped below, being let down along them to unequal depths. In this way horsts have been left standing within the field of subsidence."

Considering the vast extent of the area involved it is regarded as impossible to explain the situation from local causes, and the author is led to assume the existence of tensions in the outer crust of the earth: the phenomena being due to a rending asunder caused by contraction, the fissures having opened from above downwards. The author's general conclusions with regard to dislocations of great magnitude are that they have resulted from movements caused by diminution in the volume of the planet.

Great part of the present work is taken up with an account of the influence of the Asiatic system of disturbances on the European and other areas, and the structure of the Alpine regions is described in considerable detail. The repetition of foldings along the same lines is discussed, and in the course of the work the relations between the great geological systems in different areas are dealt with. Brittany, the London Basin, the Mendips, South Wales, and Malvern all come under notice; likewise the mountain regions of North America and Northern Africa, the main features of Australasia and Polynesia, the festoons of islands, and the mountain system of the Andes.

In order fully to grasp the complicated structures and the sequence of events discussed by the author, each volume must be read steadily through with the aid of maps; and we are glad to learn that the fifth and concluding volume will comprise the plates to which reference

is made in the present book, together with an index to the complete work. Without the index casual reference has been almost impossible, as the reader is confronted so often with new terms that a long search may have to be made before the explanations can be found.

We are taken round the world again and again in different portions of the work, when the author is dealing with the movements and foldings of particular ages, or with diverse types of scenery; and throughout the work, as we have already noted, there are disquisitions on many other subjects of wide interest, palæontological, lithological, and stratigraphical.

In treating of "The Depths" the author discusses the subject of Vadose and Juvenile waters: the former being the surface, ground, and artesian waters; the latter being those formed during volcanic eruptions, from hydrogen derived from the earth's interior combining with oxygen in the atmosphere. "Thus with every volcanic eruption the quantity of vadose water present on the earth's surface is increased."

The subject leads on to the origin of volcanoes, of ore-deposits, and diamond-pipes, and is followed by some account of the origin of the moon and the consequences of the occurrence of "invisible mountains" beneath the earth's surface, and the deflexion of the plummet: topics which we can only thus briefly mention.

On the subject of zones and sediments there are many observations of interest in connexion with contemporaneous sediments which differ lithologically and palæontologically in different areas; but this matter is not free from special, and not always very familiar, terms. Thus we are told (p. 151) that "purely heteropic heterotopy, i.e. a difference between contemporaneous formations at places remote from one another, always implies the existence of transitions". Further on we read: "In most cases, it is true, the sediment and the fauna change simultaneously, and it is this holisopy which facilitates the delimitation of the stages in nature." Remarks are made on the occurrence of perfectly white sediments in limestone formations, sediments devoid of the terrigenous element, and distinguished by an unusual abundance of organic remains. Again, we read of a stage in the Lias which, like that of *Schlotheimia marmorata*, for example, is only represented by a frequently interrupted crust of brown iron ore; a statement which reminds us of J. F. Blake's remark on a particular Ammonite zone which was locally so thin that there was no room in it for the zonal species.

The highly interesting researches of Professor H. S. Williams on the Devonian zones in North America and the interdigitation of different marine faunas receive attention.

In the concluding chapter, after mentioning that "we know nothing of the origin of life", the author discusses the distribution of plants and animals and climatic changes, and points out that the view of the permanence of oceanic basins is untenable. The incoming of new faunas in areas not subject to great physical disturbances is also dealt with, and the author describes certain "places of refuge", remarking: "If, however, we consider carefully the actual surface of the earth, we shall perceive that there are tracts in which terrestrial

forms of life have been protected from the action of such physical changes, as transgressions and mountain building, for a very long period. There are regions which since the time of the great disturbances of the Upper Carboniferous have been practically untouched by such movements, and the history of these—extending over a very long period, as a rule from the Lower Gondwána down to the present day—is solely represented by the remains of successive land floras; marine sediments are completely absent. It is true that in these places life was not exempt from the influence of climatic changes, nor from economic disturbances produced by the immigration of invading organisms, nor even from the effects of complete subsidence beneath the sea; nevertheless, floras followed one upon another in successive development, and the living world was less molested in these places than elsewhere: we shall therefore term them *asylums*."

We have referred to the author's view on the diminution of the earth's circumference. In his final sentences he remarks: "If there were even a remote tendency in the contraction of the planet to establish a new, uniform radius; if the Atlantic subsidences which cut through our most valuable asylums, have actually been produced by an effort to establish planetary equilibrium; then we should have to fear a progressive diminution of the area inhabitable by land and freshwater animals. Not life itself, but a very important, and indeed the most highly organized, part of it would be doomed to final destruction, and would be restored to the pan-Thalassa. In face of these open questions let us rejoice in the sunshine, the starry firmament, and all the manifold diversity of the Face of the Earth, which has been produced by these very processes, recognizing, at the same time, to how great a degree life is controlled by the nature of the planet and its fortunes."

II.—Memoirs of the Geological Survey.

The Geology of the Melton Mowbray District and South-East Nottinghamshire. By G. W. Lamplugh, F.R.S., W. Gibson, D.Sc., C. B. Wedd, B.A., R. L. Sherlock, B.Sc., and B. Smith, M.A.; with notes by C. Fox-Strangways, F.G.S. 8vo; pp. vi, 118, with 4 plates and 10 text-illustrations. London, 1909. Price 2*s.* 3*d.*

THE area here described is largely a clay-district of Red Marl, Lower Lias, and Boulder-clay. It extends on the south from Loughborough Station, Quorndon, and Barrow-upon-Soar to Melton Mowbray, and on the north into the Vale of Belvoir; and it is perhaps most widely known as a hunting country. From a geological point of view it includes an unbroken sequence of strata from the Keuper Marls to the Lincolnshire Limestone, a series largely concealed by the Drift deposits.

The memoir is an explanation of Sheet 142 of the new series colour-printed map, which is accompanied as usual by a geological section. This does not show the oldest strata proved in the area, which comprise Coal-measures that have been reached by borings beneath

Keuper Marls and Waterstones at Ruddington, Owthorpe, and Edwalton. Detailed descriptions are given of the Secondary formations and of the fossils and zones in the Rhætic beds, Lias, and Inferior Oolite. The Gypsum in the Keuper Marls, the Lime and Cement Works at Barnstone and Barrow-upon-Soar, and the Brown Iron-ore of the Middle Lias, form the chief economic products in the strata, and a useful map is given to show the distribution of the ironstone. Among the plates are good views of the hydraulic limestones of Barrow, of a contortion in the same formation (resembling a sharp anticline that was to be seen at Rugby), and of an ironstone working at Warnatby.

A full account is given of the Glacial Deposits, and it is noted that the authors have been unable to follow the details of Mr. R. M. Deeley's rather complex classification. Three types of Boulder-clay are, however, noted, the main Chalky Boulder-clay, a grey clay derived mostly from the Lower Lias, and a red silty clay derived apparently from the Keuper Marl. The variations in the Boulder-clay and the distribution of included boulders are marked on a small map. The evidence shows that the ice-flow was mainly from N.E. to S.W.

The whole of the area is in the Trent drainage system. The older river gravel is considered to represent late Glacial flood-deposits, and from them remains of mammoth have been recorded. The newer deposits of river gravel and the Alluvium are briefly described, and special attention has been given to the soils on the Keuper Marl, Lias, and Drift.

III.—Geological Map of Scotland. By Sir Archibald Geikie, K.C.B., D.C.L., Pres.R.S. Scale 10 miles to an inch. Second edition, with Explanatory Notes. pp. 31. Edinburgh: John Bartholomew & Co., 1910. Price 7*s.* 6*d.* net.

EIGHTEEN years have elapsed since we called attention to the first edition of this map (Geol. Mag., November, 1892); and we now welcome a revised edition, which embodies the later published work of the Geological Survey. The divisions shown in the Index of Colours are practically the same, the Lower Silurian being now taken to include Arenig as well as Caradoc and Llandeilo; while the Old Red Sandstone, subdivided as before into Upper and Lower, has two colours for the lower strata, those north and those south of the Grampians. The principal changes in the map are in the Isle of Arran, where Trias replaces much area formerly coloured as Old Red Sandstone, in the details of Islay, Colonsay, and Gigha, in the country between Oban and Inverary, Rannock Moor, and Blair Athole, and on the borders of Sutherland and Caithness. A considerable amount of geological detail and much topographical information are shown with great clearness on the map. The accompanying explanatory notes have been amplified, more especially with regard to the Volcanic rocks, the Dalradian schists, the Downtonian, and the Old Red Sandstone.

REPORTS AND PROCEEDINGS.

Geological Society of London: Annual General Meeting.

1. *February* 18, 1910.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The Reports of the Council and of the Library and Museum Committee, proofs of which had been previously distributed to the Fellows, were read. It was stated that the number of Fellows elected during the past year was 64 (as compared with 52 in 1908). Of these, 40 paid their Admission Fees before the end of the year, making, with 15 previously elected Fellows, a total accession of 55 in the course of 1909. The losses by death, resignation, and removal amounted to 44 (3 less than in 1908), the actual increase in the number of Fellows being, therefore, 11 (as compared with an increase of 5 in 1908). The total number of Fellows on December 31, 1909, was 1294.

The Balance Sheet for that year showed receipts to the amount of £3089 8*s*. 4*d*. (excluding £2000, the amount of the Sorby and Hudleston Bequests, and the Balance of £198 0*s*. 2*d*. brought forward from 1908) and an Expenditure of £3125 19*s*. 4*d*.

The Report of the Library and Museum Committee enumerated the extensive additions made during 1909 to the Society's Library, and gave details of the progress accomplished by Mr. C. D. Sherborn in the compilation and arrangement of the great Card Catalogue.

The Reports having been received, the President requested the permission of the Fellows to send a telegram of congratulation to Emeritus Professor E. Suess, F.M.G.S., and, this permission having been granted with acclamation, the following telegram was immediately dispatched to Vienna:—

"Professor E. Suess, Afrikanergasse, 9 Wien, II. The Geological Society, assembled at its Annual Meeting, sends greeting, and offers its congratulations to the veteran author of *Das Antlitz der Erde* on the completion of his great work.—Sollas, President."

The President then handed the Wollaston Medal, awarded to Professor William Berryman Scott, F.G.S., to the American Ambassador for transmission to the recipient, addressing the Ambassador as follows:—

Mr. Whitelaw Reid,—The Council of the Geological Society has awarded the Wollaston Medal, the highest honour which it can confer, to Professor William B. Scott, in recognition of his distinguished services to Geology, especially by his brilliant researches into the Mammalia of the Tertiary Era.

It is now many years since Professor Scott learnt from our famous masters, Huxley and Gegenbaur, all that the old world had to teach touching the comparative anatomy of the Vertebrata. Since then, by his admirable researches on the extinct mammals of both North and South America, he has helped to bring the New World into equal authority with the Old.

More than a quarter of a century ago he undertook, in company with his friend Professor Osborn, those exploratory expeditions into the West of the United States which succeeded in exhuming from the Tertiary rocks the debris of successive mammalian faunas, and returned to the museums of the East laden with the spoils of the past. Illumined by his genius, this material has gradually taken form, and

now reveals to an admiring world the ancestral history of diverse existing mammals, such as the Camel, the Rhinoceros, and the Dog.

More recently he organized an expedition into Patagonia, which, during three years of activity, proved equally fertile in results. These are now being set forth in a series of exhaustive monographs, to which Professor Scott has already contributed a masterly account of the genealogy of the Rodents and of the Edentata.

In his comprehensive grasp of the manifold relations which unite the great complex of the animal world, and by his philosophic conceptions of the course of organic evolution, Professor Scott ranks among the select few whom the future will number among the great palæontologists of the illustrious past.

In asking you to receive this Medal for him, I beg you to assure him of the deep interest with which the Society follows his investigations, and to express the hope that he may live long to enrich our Science with discoveries no less important than those which we now celebrate.

The Hon. Whitelaw Reid replied in the following words:—

Mr. President,—I have much pleasure in appearing before this learned body, on behalf of my distinguished countryman, Professor Scott, to receive this Medal for him and in his name.

I may venture also to assure you of his warm thanks, and of the high appreciation with which the great honour that you have thus conferred—the greatest within your gift—will be regarded by Professor Scott himself, and by the noted and very important institution with which he is connected—Princeton University, or 'Old Nassau', as its *alumni* love to call it.

You have enhanced this honour by the cordial and gracious language in which you have been pleased to extend it. It is enhanced also by what I may perhaps call its family origin. We all know too well how family disputes are apt to be the worst and sometimes the most dangerous. Just so, no recognition of success is so sweet as that from the circle of kindred. A generous tribute like this, from the authoritative body of geologists in one branch of the great English-speaking family, for good work done by a leader in that important science in another branch of the same family, is peculiarly grateful to the recipient himself, and grateful also, as well as helpful and inspiring, to his University, to his friends, and in general to his countrymen.

The President then handed the Murchison Medal, awarded to Professor Arthur Philemon Coleman, to the Right Hon. Lord Strathcona and Mount Royal, G.C.M.G., High Commissioner for the Dominion of Canada, for transmission to the recipient, addressing him as follows:—

Lord Strathcona,—The Murchison Medal is awarded to Professor Coleman in recognition of his important contributions to geological science.

During his long and distinguished occupation of the Chair of Geology in the University of Toronto, he has added largely to our knowledge of the history and formation both of the stratified systems and of the igneous rocks of Canada; nor has he restricted his attention to these, but has thrown much light on the origin of some of its most interesting scenery. He has travelled far and wide, and, bringing to bear the vast stores of information gathered in his journeys through North America, Europe, and Africa, he has increased the value of his researches by making use of the comparative method. The deposits of nickel ore at Sudbury have yielded to his investigations conclusions of fundamental importance, which have been recognized and enforced by the veteran author of *Das Antlitz der Erde*. No less important are the results of his researches on the Pleistocene Series in the vicinity of Toronto. His latest achievement—the discovery of glacial deposits in the Lower Huronian rocks of Canada—extends the evidence of uniformity into the remote past of the Protæon.

I had many opportunities of admiring the enthusiasm and energy of Professor Coleman, when we were fellow-hammerers on the Dwyka Conglomerate, and it is with peculiar pleasure that I hand you this Medal, which I beg you to be good enough to transmit to him.

Lord Strathcona said—

that he was greatly honoured and pleased to be the medium of transmitting the Medal to Professor Coleman, on whose behalf he ventured to express his warmest thanks. He added that this was not the first occasion on which he had acted as interpreter to the Canadian branch of the great English-speaking family of the high esteem in which the old Motherland held the brilliant work accomplished by Canadian geologists.

The President then presented the Lyell Medal to Dr. Arthur Vaughan, B.A., addressing him in the following words:—

Dr. Vaughan,—The Lyell Medal is awarded to you in recognition of your distinguished services to Geology, especially in establishing the order of the Faunal Succession in the Lower Carboniferous rocks of Britain.

In your earlier studies of the Jurassic zones with their teeming fossils, you acquired a mastery over the investigation of the known which enabled you to venture with confidence into unexplored regions. Thanks to your researches, the Avon Gorge, once famous for its beauty, has now become no less famous as a scale of geological time.

From all sides—Wales, Ireland, France, Belgium, Germany, and remote parts of Britain—geologists, attracted by this long-desired means of correlation, have hastened on pilgrimage to Clifton, where, under your illuminating teaching, they have been made familiar with all the mysteries of the new standard of reference.

How fortunate have been the results the pages of our Journal bear witness; our knowledge of the stratified crust has been enriched by a whole chapter, and the method of William Smith has once more achieved a triumph.

Of your power to instruct I speak with experience, for I was your pupil when last I visited the Avon section; this recollection adds to the pleasure with which, in the name of the Council, I hand you this award.

Dr. Vaughan replied as follows:—

Mr. President,—Nothing could have given me greater delight, or have come at a more opportune moment, than the news of the award to me of the Lyell Medal.

With the zeal for fresh labours partly dulled by a long illness, this eagerly desired prize came as a welcome spur, restoring self-confidence by assuring me of the sympathy of brother geologists. As yet, sir, I can only hope that, some day, I may have done more to deserve this great honour and the kind words with which you have so generously accompanied its bestowal.

My thanks are rendered heartily and, in very truth, humbly to the Council of the Geological Society and to the many Fellows who have so kindly approved of their selection. I cannot allow this unique opportunity to slip of acknowledging how much my work owes to the inspiring advocacy of two staunch and long-time friends, Professor S. H. Reynolds and Mr. E. E. L. Dixon.

In presenting the Balance of the Proceeds of the Wollaston Donation Fund to Mr. Edward Battersby Bailey, B.A., the President addressed him in the following words:—

Mr. Bailey,—The Balance of the Proceeds of the Wollaston Donation Fund has been awarded to you by the Council in recognition of the value of your investigations into the Carboniferous System of Scotland and the structure of the Glen Coe area. After carrying out successful investigations on the geology of East Lothian, especially in relation to the Glacial phenomena, the volcanic rocks, and the Coal-measures of that district, you, in your paper written conjointly with Mr. C. T. Clough and Mr. H. B. Maufe on the Caldron Subsidence of Glen Coe, analysed with great skill a structure of remarkable complexity, and succeeded in tracing the successive stages of its formation, thus obtaining results which have an important bearing on some of the obscurer problems of volcanic and tectonic phenomena.

The Society hopes that your powers of exact observation and imaginative insight may be exercised with equal success upon the new and difficult problems which again confront you in the West of Scotland.

The President then handed to Mr. John Walker Stather, F.G.S., the Balance of the Proceeds of the Murchison Geological Fund, addressing him as follows:—

Mr. Stather,—The Balance of the Proceeds of the Murchison Geological Fund has been awarded to you by the Council in recognition of the services that you have rendered to Geology, as well by fostering a love of research among your fellow-citizens in Hull as by your own investigations among the Glacial Deposits of East Yorkshire.

For almost a quarter of a century you have furnished inspiration to an active band of fellow-workers, who have worthily maintained the traditions of East Yorkshire as a centre of geological study.

To your own investigations we owe a deeper insight into the intricacies of the latest Glacial Deposits; we have learnt to discern in them successive horizons, each distinguished by characteristic boulders derived from different remote localities; we are able to trace their extension, beyond the limits once assigned to them, even on to the high Chalk Wolds; and we have gained an acquaintance in detail with the drifts of Kirmington and Beilsbeck, which possess so great an interest on account of their included fossils.

May you long continue to exercise that wisely directed energy which has enabled you, in the scanty leisure of a busy life, to achieve so much for our science.

In presenting one moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Frederick Richard Cowper Reed, M.A., the President addressed him in the following words:—

Mr. Reed,—A moiety of the Balance of the Proceeds of the Lyell Geological Fund has been awarded to you by the Council, in acknowledgment of the services that you have rendered to Geology and Palæontology, especially by your researches among the Invertebrate Fossils of Great Britain and Ireland, Africa, and India.

Since the publication of your first paper in 1892, memoirs and monographs have proceeded from your pen in an unremitting stream. Amidst work so various and voluminous, it is difficult, where all is good, to know what to select for special praise; but all will acknowledge, as enduring monuments of painstaking industry and exact research, your monographs on the Trilobites of Girvan, the Fauna of the Bokkeveld Beds, the Fossils of the Northern Shan States, and the Cambrian Fossils of Spiti.

To numerous colleagues in the field you have brought the indispensable aid of Palæontology. They will join in welcoming this award, and in expressing with me our best wishes for your continued success in the work of investigation.

The President then handed the other moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Professor Robert Broom, M.D., to Dr. A. Smith Woodward, Sec.G.S., for transmission to the recipient, addressing him as follows:—

Dr. Smith Woodward,—The Council of the Geological Society have awarded a moiety of the Balance of the Lyell Geological Fund to Professor Robert Broom, in recognition of his work on the Fossil Reptiles of the Karoo.

While practising medicine in New South Wales, Professor Broom found time to make researches into the anatomy of the Monotremes and Marsupials; these led him to reflections on the origin of the Mammalia, and, in the hope of obtaining a solution of this question, he left Australia for Cape Colony, settling in a district where, while still engaged in the practice of his profession, he could collect and study the reptilian remains of the Karoo. He has since been able to devote himself almost entirely to this pursuit, and has published a long series of memoirs which add largely to our knowledge of the Fossil Reptilia.

We trust that the Karoo has still many discoveries in store for him, and that he may be destined to throw still further light on the predecessors of the Mammalia.

The President then proceeded to read his Anniversary Address, giving first of all Obituary Notices of several Fellows deceased since the last Annual Meeting, including Mr. T. Mellard Reade (elected

a Fellow in 1872); Mr. J. E. Saunders (el. 1855); Dr. J. Whiteaves (el. 1859); Mr. H. Bauerman (el. 1863); the Marquess of Ripon (el. 1867); Mr. F. G. Hilton Price (el. 1872); Mr. H. M. Klaassen (el. 1877); Mr. W. F. Stanley (el. 1884); Mr. James Parsons (el. 1900); and Mr. E. Kelly (el. 1875).

He then dealt with the Evolution of Man in the light of Recent Investigations. Considering first the human remains of the Pleistocene Epoch, he pointed out that, so far as the evidence extends, it shows that the cranial capacity of the human skull increases rather than decreases as we pass backwards in time. The oldest known human skulls are later than the Chalky Boulder-clay. The cranial capacity is merely a morphological character of unknown significance. Observation shows that no discoverable connexion exists between it and the intellectual power.

The most recent researches in comparative anatomy emphasize the close connexion between Man and the Anthropoid Apes, especially the Gorilla and the Chimpanzee. A similar result is afforded by the investigations of Uhlenhuth and Nuttall into blood-relationship.

All recent researches converge to show that the genealogy of Man is to be traced through the Anthropoid Apes and the Catarrhine Monkeys to the Lemurs. Cope's suggestion of a direct descent from extinct Lemurs receives no confirmation. Primitive characters, when present in Man, can be better explained by regression and adaptation.

Man probably diverged from the phylum of the Primates above the point of origin of the Gibbon, and not far from that of the Gorilla and the Chimpanzee. He owed his progress in the first place to emancipation from a forest life, and commenced his career as the ape of the plains. The erect attitude and the use of the hand as a universal instrument followed as a consequence. Ancestral Man was probably a social animal at a very early period, and social life afforded a stimulus to the development of the powers of speech. He was probably distinguished by great bodily strength and by the possession of formidable natural weapons of defence and offence. With the invention of weapons made by art the necessity for natural weapons disappeared, and a regressive development of the teeth with adaptation to purely alimentary functions commenced. A purely human dentition characterizes the Heidelberg jaw, which is the oldest known. This, however, still reveals in all other respects strong simian affinities.

The growth of the brain in size and complexity might be correlated with the evolution and use of the hand, but to a far greater extent with the development of the powers of speech and the consequent exchange, multiplication, and co-ordination of ideas.

The Ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—Council: Tempest Anderson, M.D., D.Sc.; Charles William Andrews, B.A., D.Sc., F.R.S.; George Barrow; Professor William S. Boulton, B.Sc.; James Vincent Elsden, B.Sc.; Professor Edmund J. Garwood, M.A.; Sir Archibald Geikie, K.C.B., D.C.L., LL.D., Sc.D., Pres.R.S.; Alfred Harker, M.A., F.R.S.; Robert Stansfield Herries, M.A.; Finley L. Kitchin, M.A., Ph.D.; Bedford McNeill, Assoc.R.S.M.; John Edward Marr, Sc.D., F.R.S.; Horace W. Monckton, Treas.L.S.; George Thurland Prior, M.A., D.Sc.; Professor Sidney Hugh Reynolds, M.A.; Professor William Johnson Sollas, LL.D., Sc.D., F.R.S.; Aubrey Strahan, Sc.D., F.R.S.; Herbert Henry Thomas, M.A., B.Sc.;

Professor W. W. Watts, Sc.D., M.Sc., F.R.S.; Henry Woods, M.A.; Arthur Smith Woodward, LL.D., F.R.S., F.L.S.; Horace Bolingbroke Woodward, F.R.S.; and George William Young.

OFFICERS:—*President:* Professor W. W. Watts, Sc.D., M.Sc., F.R.S. *Vice-Presidents:* Charles William Andrews, B.A., D.Sc., F.R.S.; Alfred Harker, M.A., F.R.S.; Horace W. Monckton, Treas.L.S.; Professor W. J. Sollas, LL.D., Sc.D., F.R.S. *Secretaries:* Professor Edmund J. Garwood, M.A.; A. Smith Woodward, LL.D., F.R.S., F.L.S. *Foreign Secretary:* Sir Archibald Geikie, K.C.B., D.C.L., LL.D., Sc.D., Pres.R.S. *Treasurer:* Aubrey Strahan, Sc.D., F.R.S.

II. *February* 23, 1910.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communication was read:—

"Metamorphism around the Ross of Mull Granite."[1] By Thomas Owen Bosworth, B.A., B.Sc., F.G.S.

The Ross of Mull granite is a coarsely crystalline plutonic mass, forming the western portion of the Ross of Mull and extending over some 20 square miles.

The intrusion is conspicuously later than the Moine rocks, and is regarded as one of the 'newer granites'. The rock shows very little evidence of faulting or movement of any kind, and is traversed by sheets of mica-trap. The eastern boundary of the granite is a very intricate line of junction with typical Moine Schists and Gneisses, into which it has been intruded. Injection-breccias occur along the margin, where the granite is crowded with schist-inclusions.

The changes in the pelitic schists are of two kinds, and are considered under separate headings (*a*) and (*b*) below.

(*a*) *Impregnation.*—The schists have been impregnated with the granite in a very intimate manner—(1) along irregular cracks, (2) along bedding-planes, (3) along strain-slip, and (4) along foliation.

Variously banded rocks have been thus produced, which suggest how readily these processes, carried out on a large scale, would convert pelitic sediments from the state of schists into crystalline igneous gneisses.

(*b*) *Thermal Metamorphism.*—In some places the pelitic gneiss in contact with the granite, and commonly the masses included in the granite, have been very highly altered. The new minerals formed are sillimanite, andalusite, cordierite, and green spinel; and these are present in such amount that their formation must have been accompanied by much recrystallization among the quartz, felspar, and mica also.

Sillimanite is the most abundant new mineral, and occurs not only as fibrolite throughout the rock, but also in larger crystals which are often grouped together in prismatic aggregates. These aggregates weather out as conspicuous knobs, measuring about an inch across.

Under the microscope, the sillimanite is seen to enclose large numbers of grains of green spinel. The cross-sections of sillimanite are diamond-shaped, and show a pinacoidal cleavage; their colour

[1] Communicated by permission of the Director of H.M. Geological Survey.

between crossed nicols is a very low grey, and good interference-figures are obtained.

The association of minerals in the schists is the same as that noticed at the margin of the Ben Cruachan 'newer granite' mass, and also at the margin of 'newer granite' at Netherly in Elgin.

Tourmaline, kyanite, and staurolite also occur in the Moine Schists of Mull, but are in no way connected with the granite.

CORRESPONDENCE.

CAPE COLONY.

SIR,—In the review of the work by Dr. Rogers and Mr. Du Toit (GEOL. MAG., December, 1909, p. 561) attention was called to the absence of references to authorities *in the index*, not in the text.

REVIEWER.

March 17, 1910.

THE MEANING OF THE TERM 'LATERITE'.

SIR,—In discussing the meaning of the term 'laterite', I have at least the qualification of an intimate acquaintance with the material to which the name was first given in the area in which it is typically developed.

As I understand Mr. Scrivenor, he contends that whatever may have been its original signification, it has been so widely employed in other senses that it should be dismissed from scientific language, the more so as the word 'bauxite' is available to replace it.

It must be remembered, however, that bauxite is a mineral name indicating a substance containing approximately two molecules of water to one of alumina, whatever may be its true chemical constitution. The bauxite of the type locality, Baux near Arles in the south of France, is believed to have resulted from the action of aluminium sulphate on limestone, but this is only one way in which such a product might have been formed.

Laterite, on the other hand, is a rock name given to a widespread clay-like deposit which plays a conspicuous part in the surface features of Peninsular India. It has recently been recognized with similar characters in other tropical countries, and has been shown by the classical researches of Max Bauer, Warth, and Holland to be formed by the surface decomposition of alumina-bearing crystalline rocks, whereby the alkalies, alkaline earths, and combined silica are to a large extent removed, leaving behind the free silica, the titanium oxide, and the oxides of alumina and iron, which have taken up water to form hydrates.

This well-characterized formation obviously requires a special designation, and what could be more suitable than the name that Buchanan applied to it over a century ago, and which is still employed in the Peninsula in the same sense in scientific, technical,

and popular language. Mr. Scrivenor appeals to the usage of engineers, but to the best of my recollection I never heard the term applied to any other material by a South Indian engineer during my four years' residence in the State of Mysore.

Curiously enough, at the date of the publication of the second edition of the Manual of the Geology of India in 1893, no complete analysis of laterite from the Peninsula of India was known, and its characteristic chemical composition was still unrecognized. Since that date numerous analyses of laterites from widely distant tropical localities have been made. The most recent information on the subject may be obtained from a second paper by Max Bauer (*Neues Jahrb. für Min.*, etc., Festband, 1907, pp. 33–90), a report from the Imperial Institute on specimens from the Balaghat District of the Central Provinces of India (Rec. Geol. Surv. Ind., 1908, vol. xxxvii, pp. 213–20; Bull. Imp. Inst., 1909, vol. vii, pp. 278–85), both of which contain full information on previous literature and analyses, and an interesting contribution by J. Chantard & P. Lemoine (*Comptes Rendus Acad. Sci.*, vol. cxlvi, pp. 239–42; *Bull. Soc. de l'Indust. Min. St. Étienne*, 1909, ser. iv, vol. ix, pp. 1–37), in which are traced out the changes that have taken place in the formation of laterite on the assumption that the amount of titanium oxide has remained unaltered.

As a result of the work that has been done it is found that the chemical composition of laterite varies within wide limits according to the nature of the original rock, so that it is not necessarily the same as that of bauxite. One feature, however, remains constant—the small amount of combined silica in proportion to the alumina present, and it is in this respect that laterites differ from clays, which also occur as tropical decomposition products and are sometimes incorrectly described as laterites. If, again, the amount of ferric oxide is large, it is apt to form ferruginous concretions, which are commonly referred to as *lateritic iron ore*; and if, as sometimes happens, the aluminium hydrate is in course of time washed away, an accumulation of scoriaceous iron ore may be left behind which is certainly not laterite, though it may be derived from it. It is probably this which has given rise to the misuse of the term for surface iron ore, which is common in some of our colonies.

It would be difficult to conceive a stronger case for the application of the rule of priority than the present. The term laterite was applied as early as 1807 to a well-marked rock type, and has continued in use ever since with the same signification, which has been adopted by writers on tropical geology in Germany and France, and received the endorsement of authorities like Keyser (*Lehrbuch*, 1909, vol. i, pp. 282–3). At the same time it has met with general acceptance in this country. Yet we are told that it must be abandoned because it has been wrongly employed by Colonial engineers who are unacquainted with the material to which it is properly applied.

John W. Evans.

Imperial Institute, S.W.

OBITUARY.

HENDERICUS M. KLAASSEN, F.G.S.

Born 1828. Died January 22, 1910.

We regret to record the death at Croydon, in his 81st year, of Mr. H. M. Klaassen. He was born at Kritzum in Hanover, where his father was the minister of the Dutch Reformed Church. After the ordinary school education in his native town he was trained for business, and in his twentieth year he came to England, and having gained experience he started on his own account as a seed factor on the London Corn Exchange in Mark Lane. The undertaking was successful, so that he was enabled to retire from business in 1874. He then followed his natural bent toward science, and attended the courses of lectures on Chemistry, Zoology, and Geology at University College, London. His predilection for this last-named science was greatly stimulated by John Morris, at that time Professor of Geology at the College, and he was induced to join the Geologists' Association in 1875, and was elected a Fellow of the Geological Society in 1877.

In 1883 Mr. Klaassen contributed a paper, "On a Section of the Lower London Tertiaries at Park Hill, Croydon," to the Proceedings of the Geologists' Association, in which a detailed description was given of the character of the beds and their fossils exposed in a deep cutting on the Woodside and South Croydon Railway. During the eighteen months the cutting was in progress Mr. Klaassen visited the work regularly every day, and thus secured a complete record of the beds exposed, and moreover he discovered some fossil bones which were described by Mr. E. T. Newton, F.R.S., as in part belonging to a new species of mammal which was named *Coryphodon Croydonensis*, and in part to a gigantic species of bird, larger than an ostrich, which received the name of *Gastornis Klaasseni*[1] in honour of its discoverer.

A second paper by Mr. Klaassen, "On the Pebbly and Sandy Beds overlying the Woolwich and Reading Series on and near the Addington Hills, Surrey," was contributed to the Proc. Geol. Assoc. in 1890.

Mr. Klaassen was an earnest supporter of the Croydon Natural History and Microscopical Club, and he took a prominent part in founding a school in Croydon for the secondary education of girls in connexion with the Girls' Public Day School Company. Endowed with a genial temperament and sound judgment he won the regard of numerous friends, by whom his memory will be kindly cherished.

ROBERT MARCUS GUNN, M.A., F.R.C.S., F.G.S.

Born 1850 (?1851). Died December 2, 1909.

Mr. Gunn, who was a distinguished ophthalmic surgeon, had devoted his leisure during many years to the collection and study of fossils. Born at Dunnet, in Caithness, he belonged to the Clan Gunn, and was son of Marcus Gunn of Culgower, on the eastern coast of Sutherland.

[1] See E. T. Newton, "On a Gigantic Bird from the Lower Eocene of Croydon, *Gastornis Klaasseni*, Newton": Proc. Zool. Soc., May 5, 1885, and Geol. Mag., 1885, p. 362.